

Work Plan

67

For

Focused Site Inspection

**Surface Warfare Officers School
Naval Station Newport
Newport, Rhode Island**



**Engineering Field Activity Northeast
Naval Facilities Engineering Command**

Contract Number N624767-94-D-0888

Contract Task Order 0842

January 2005

WORK PLAN
FOR
FOCUSED SITE INSPECTION

SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Northeast
Environmental Branch, Code EV2
Naval Facilities Engineering Command
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TABLE OF CONTENTS

SECTION		PAGE
1.0	INTRODUCTION	1-1
1.1	SITE-SPECIFIC INVESTIGATION OBJECTIVES	1-1
1.2	PROJECT ORGANIZATION AND RESPONSIBILITIES	1-2
1.3	PROJECT DELIVERABLES	1-4
1.4	WORK PLAN ORGANIZATION	1-5
1.5	CHANGES TO THE WORK PLAN	1-5
1.6	SCHEDULE AND REGULATORY OVERSIGHT	1-6
2.0	BACKGROUND INFORMATION	2-1
2.1	SITE LOCATION	2-1
2.2	SITE DESCRIPTION	2-1
2.3	PREVIOUS SITE INVESTIGATIONS AND HISTORY	2-5
2.4	GEOLOGY AND HYDROGEOLOGY	2-9
2.4.1	Regional Geology	2-9
2.4.2	Regional Hydrogeology	2-9
2.4.3	Site Geology and Hydrogeology	2-10
2.5	SITE WASTE CHARACTERISTICS	2-11
2.5.1	Potential Off-Site Contamination Sources	2-12
2.6	DATA QUALITY OBJECTIVES	2-14
2.6.1	Statement of the Problem	2-14
2.6.2	Identification of the Decision	2-14
2.6.3	Inputs to the Decision	2-15
2.6.4	Definition of the Study Boundaries	2-15
2.6.5	Decision Rule	2-16
2.6.6	Limits on Decision Errors	2-16
2.6.7	Design for Obtaining Data	2-16
3.0	FIELD INVESTIGATION AND SAMPLING PLAN	3-1
3.1	INTRODUCTION	3-1
3.2	TASK 1: RECONNAISSANCE SURVEY AND RECORDS SEARCH	3-1
3.3	TASK 2: GEOLOGIC/HYDROGEOLOGIC INVESTIGATION AND ENVIRONMENTAL SAMPLING	3-2
3.3.1	Advancement of Borings	3-3
3.3.2	Soil Sampling	3-7
3.3.3	Groundwater Monitoring Points	3-9
3.3.4	Well Development	3-13
3.3.5	Groundwater Sample Collection	3-14
3.4	TASK 3: LAND SURVEY	3-18
3.5	INVESTIGATION-DERIVED WASTE (IDW)	3-19
3.5.1	Solid Wastes	3-19
3.5.2	Soil Wastes	3-19
3.5.3	Liquid Wastes	3-20
3.6	DECONTAMINATION PROCEDURES	3-20
4.0	QUALITY ASSURANCE/QUALITY CONTROL	4-1
4.1	PARCC PARAMETERS	4-2
4.1.1	Precision and Accuracy	4-2
4.1.2	Representativeness	4-3
4.1.3	Completeness	4-3
4.1.4	Comparability	4-4

TABLE OF CONTENTS (cont.)

<u>SECTION</u>		<u>PAGE</u>
4.2	QUALITY CONTROL SAMPLES.....	4-4
4.2.1	Field Duplicates	4-4
4.2.2	Rinsate Blanks.....	4-5
4.2.3	Source Blanks	4-5
4.2.4	Trip Blanks.....	4-5
4.2.5	Matrix Spike/Matrix Spike Duplicates	4-5
4.3	PROJECT ACTION LIMITS AND METHOD DETECTION LIMITS	4-6
4.4	SAMPLE DESIGNATION AND CUSTODY	4-7
4.4.1	Sample Numbering.....	4-7
4.4.2	Sample Chain of Custody.....	4-20
4.5	CALIBRATION PROCEDURES	4-21
4.6	LABORATORY ANALYSIS	4-21
4.7	DATA REDUCTION, REVIEW, AND REPORTING	4-21
4.8	INTERNAL QUALITY CONTROL.....	4-22
4.9	PERFORMANCE AND SYSTEM AUDITS	4-22
4.10	DATA ASSESSMENT PROCEDURES	4-22
4.10.1	Representativeness, Accuracy, and Precision	4-22
4.10.2	Data Validation	4-23
4.11	CORRECTIVE ACTION	4-23
4.12	DOCUMENTATION.....	4-24
5.0	REPORTING.....	5-1
5.1	FOCUSED SI REPORT.....	5-1
5.2	DATA ASSESSMENT	5-2
6.0	REFERENCES.....	6-1

TABLES

<u>NUMBER</u>		<u>PAGE</u>
3-1	Proposed Field Samples	3-5
3-2	Well Installations/Soil Borings	3-6
3-3	Sample Container, Preservative, and Holding Time Requirements.....	3-11
3-4	Field Quality Control Sample Summary	3-12
4-1A	Soil - Volatile Organic Target Analytes, Method 5035/8260B	4-8
4-1B	Soil - Semivolatile Organic Target Analytes, Method 8270C	4-10
4-1C	Soil - Pesticides/PCB Target Analytes, Methods 8081/8082.....	4-12
4-1D	Soil - Metals Target Analytes Method 6010B and 7471A.....	4-13
4-2A	Groundwater - Volatile Organic Target Analytes, Method 8260B.....	4-14
4-2B	Groundwater - Semivolatile Organic Target Analytes, Method 8270C.....	4-16
4-2C	Groundwater - Pesticide/PCB Target Analytes, Method 8081/8082	4-18
4-2D	Groundwater - Metals Target Analytes, Method 6010B/7470A	4-19

TABLE OF CONTENTS (cont.)

FIGURES

<u>NUMBER</u>		<u>PAGE</u>
2-1	Site Locus	2-2
2-2	NAVSTA Newport Sites and Study Areas	2-3
2-3	SWOS Location Map	2-4
2-4	Aerial Photograph - 1944	2-6
2-5	Aerial Photograph - 1962	2-7
2-6	Aerial Photograph - 1996	2-8
2-7	2003 Test Pitting and Soil Sampling Locations.....	2-13
3-1	Sample Locations	3-4

APPENDICES

- A Site Specific Health and Safety Plan
- B TtNUS Standard Operating Procedures
- C TtNUS Field Documentation Forms
- D Final Report and Risk Assessment for Worker Exposure at the SWOS Site

1.0 INTRODUCTION

This work plan has been prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62467-94-D-0888, Contract Task Order (CTO) 842. A Focused Site Inspection (SI) work plan for the Surface Warfare Officers School (SWOS) site, located at Naval Station Newport (NAVSTA Newport) in Middletown, Rhode Island is to be completed by Tetra Tech NUS, Inc. (TtNUS) on behalf of the Navy. This work plan outlines the requirements and describes the procedures for performing investigations at this site.

The purpose of this work plan is to describe the investigation necessary to characterize the nature of environmental contamination at the SWOS site in order to prepare a Focused SI report in accordance with the Federal Facilities Interagency Agreement (FFA) between the United States Environmental Protection Agency (USEPA), the Rhode Island Department of Environmental Management (RIDEM), and the U.S. Navy for CERCLA Sites at NAVSTA Newport. Response action requirements under the Department of Defense Installation Restoration Program (IRP) at NAVSTA Newport are outlined in the FFA.

1.1 SITE-SPECIFIC INVESTIGATION OBJECTIVES

The project objective will address the nature of contaminants present on the SWOS site, as well as, a possible relationship of this site to the adjacent Old Fire Fighting Training Area (OFFTA) site (Site 09). Specifically, the Focused SI will assess the presence of contamination in soils and groundwater through a focused investigation program.

The nature of the contamination at the SWOS site will be evaluated by comparing chemical data to pertinent state and federal criteria as well as the background data set established for the OFFTA site. In addition, a preliminary data assessment will be performed as is consistent with the scope of the Focused SI.

The Focused SI activities will include file reviews, background information research (aerial photographs, land use records, etc.), a site reconnaissance survey, advancement of soil borings and installation of micro wells, soil and groundwater sampling, laboratory analysis, surveying, and investigative derived waste removal. Details of these activities are provided in Section 3.0.

The scope of work for the SWOS Focused SI was developed based on information collected in support of the Phase I Environmental Site Assessment (TtNUS, 2001) and the Final Report and Risk Assessment for Workers Exposure at the SWOS Site (Foster Wheeler Environmental Corporation, 2003). Oily soils

were encountered on the SWOS site during construction of the SWOS Applied Instruction Building. This investigation is intended to document the presence of, and potential for, environmental contamination. Data will be collected and may be used in a risk assessment in the future if deemed necessary. The findings of this Focused SI will determine if subsequent investigations or removal actions are necessary. The findings may be used in accordance with a subsequent Remedial Investigation, if one is deemed necessary, to evaluate remedial actions at the site through the performance of a feasibility study.

The objectives of this Focused SI are described in detail through the formulation of data quality objectives in Section 2.6 of this work plan.

1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

TtNUS will be responsible for the overall management of the project, including the performance of field activities presented in this work plan.

NAVFAC personnel will be responsible for administrative and technical oversight of the program, project management and coordination between state or federal regulatory agencies, while the NAVSTA Newport on-site representative will be responsible for on-site coordination with TtNUS.

Key Navy personnel supporting this project are as follows:

- Curtis Frye, P.E., RPM
EFANE, NAVFAC
- Comelia Mueller, Facility Contact
NAVSTA, Public Works Department Environmental

Key TtNUS personnel supporting this project are as follows:

Tetra Tech NUS, Inc., Wilmington, MA

Phone: (978) 658-7899

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- Stephen Parker, L.S.P.
Project Manager

- Cynthia Woods
Human Health Risk Assessment

Tetra Tech NUS, Inc., Pittsburgh, PA

Phone: (412) 921-7090

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- Matt Soltis
TtNUS CLEAN Program Health and Safety Manager
- Paul Frank
TtNUS CLEAN Program Quality Assurance Manager
- Kelly Carper
TtNUS CLEAN Lead Chemist

The TtNUS Project Manager (PM) will have the primary responsibility for implementing and managing the Focused SI. The TtNUS Project Manager will also be responsible for notifying regulatory agencies of field activities or schedule modifications. A Field Operations Leader (FOL) and lead technical staff will be appointed to support the PM.

The CLEAN Health and Safety Manager is responsible for reviewing health and safety plans for all CLEAN operations, and performs site audits to ensure compliance with site health and safety requirements.

The Quality Assurance Manager is responsible for QA/QC requirements for the TtNUS CLEAN program. This individual reviews data and deliverable documents, and performs system audits to ensure contract QA/QC goals are met.

The Lead Chemist will advise the PM on technical requirements of the data and sample collection efforts. This individual will also assume a second role as site QA/QC officer.

A Lead Geologist will be appointed to direct technical work relating to the geologic and hydrogeologic investigations. The Lead Geologist will advise the PM on technical requirements relating to these tasks. Direction of certain subcontractors may be delegated from the FOL to the Lead Geologist (i.e. drilling). This individual will also coordinate the efforts of the field geologists with the FOL and the Project Manager to ensure the goals of the task are met.

The FOL will be responsible for directing on-site field activities and will report directly to the PM. The FOL will coordinate efforts of the field sampling staff, the subcontractors, and the lead technical staff. The FOL will be responsible for identifying problem areas and bringing them to the attention of the PM for resolution.

A Site Safety Officer (SSO) will be designated prior to field activities and will be responsible for the adherence to all health and safety requirements. The SSO reports directly to the CLEAN Health and Safety Manager and the PM.

The Lead Risk Assessment personnel will be responsible for reviewing the sampling program to ensure it is adequate to meet the objectives of the study, for assimilation of the data into a format that is amenable to the manipulations that are required for risk evaluation, and for the performance of the risk evaluations.

In addition to the above personnel, TtNUS program personnel will provide overall support in subcontracting, cost tracking, progress reporting, and supervising the project manager. The program personnel include the following:

John Trepanowski, P.E.
Program Manager

Garth Glen
Deputy Program Manager

Tetra Tech NUS, Inc., King of Prussia, PA
Phone: (610) 491-9688
Fax: (610) 491-9647

1.3 PROJECT DELIVERABLES

Project deliverables submitted during this project will include:

- Internal Draft, Draft, Draft Final, and Final Work Plan for review
- Internal Draft, Draft, Draft Final, and Final Focused SI report.

A detailed description of the Focused SI report is presented in Section 5.0 of this work plan.

1.4 WORK PLAN ORGANIZATION

Section 1.0, Introduction, of this work plan contains the site-specific investigation objectives, project and work plan objectives, and schedule.

Section 2.0, Background Information, describes the history of the site and the findings of previous investigations of both the site and the surrounding areas of possible concern.

Section 3.0, Field Investigation and Sampling, presents the field work required for this investigation. Tasks are listed in chronological order of execution. Sample collection procedures and analytical parameters are also described in this section.

Section 4.0, Quality Assurance/Quality Control, presents the Quality Assurance Plan for the Focused SI. This plan describes the QA/QC sample collection procedures and frequencies, data quality protocols, and analytical data validation requirements.

Section 5.0, Reporting, presents a brief description of the Focused SI report and data assessment that will be prepared following completion of all the field work described in Section 3.0 of this work plan.

Section 6.0 lists the references used in this work plan.

A site-specific Health and Safety Plan is attached as Appendix A. Appendix B presents Standard Operating Procedures (SOPs) for the field investigation work. Appendix C contains samples of forms to be used for documentation during this investigation.

1.5 CHANGES TO THE WORK PLAN

If, during the field investigation, the plan for collection of data needs to be altered, the work plan may be amended through the use of a Field Modification Request (FMR). This form will be prepared by the TtNUS FOL and forwarded to the TtNUS PM. The TtNUS PM makes a recommendation to the Navy RPM, who (if necessary) will forward the FMR to the regulatory oversight RPMs. Time limits on acceptance of, or comment to, the field modification requests will be stated. An example of this form is presented in Appendix C.

1.6 SCHEDULE AND REGULATORY OVERSIGHT

A schedule for field investigations has not been prepared at this time. However, several activities may warrant regulatory oversight. A schedule will be prepared and submitted to the USEPA and RIDEM upon development of a cost/schedule proposal to perform the field work. This schedule will be updated as necessary to inform oversight personnel when different tasks and activities are scheduled to occur.

Field sampling is planned to occur in a single phase effort. Any changes in the number or location of proposed soil borings or monitoring wells will be discussed with RIDEM and USEPA prior to initiation of the associated phase of fieldwork.

A 24-hour advance notification of changes in scheduled field activities will be given to the regulatory agencies.

2.0 BACKGROUND INFORMATION

The information provided in this section and some of Section 3.0 has been adapted from the Final Report and Risk Assessment for Worker Exposure at the SWOS Site (Foster Wheeler Environmental Corporation, 2003), Phase I Environmental Site Assessment for SWOS Building Site (TtNUS, 2001) and the Final Initial Assessment Study report (Envirodyne, 1983).

2.1 SITE LOCATION

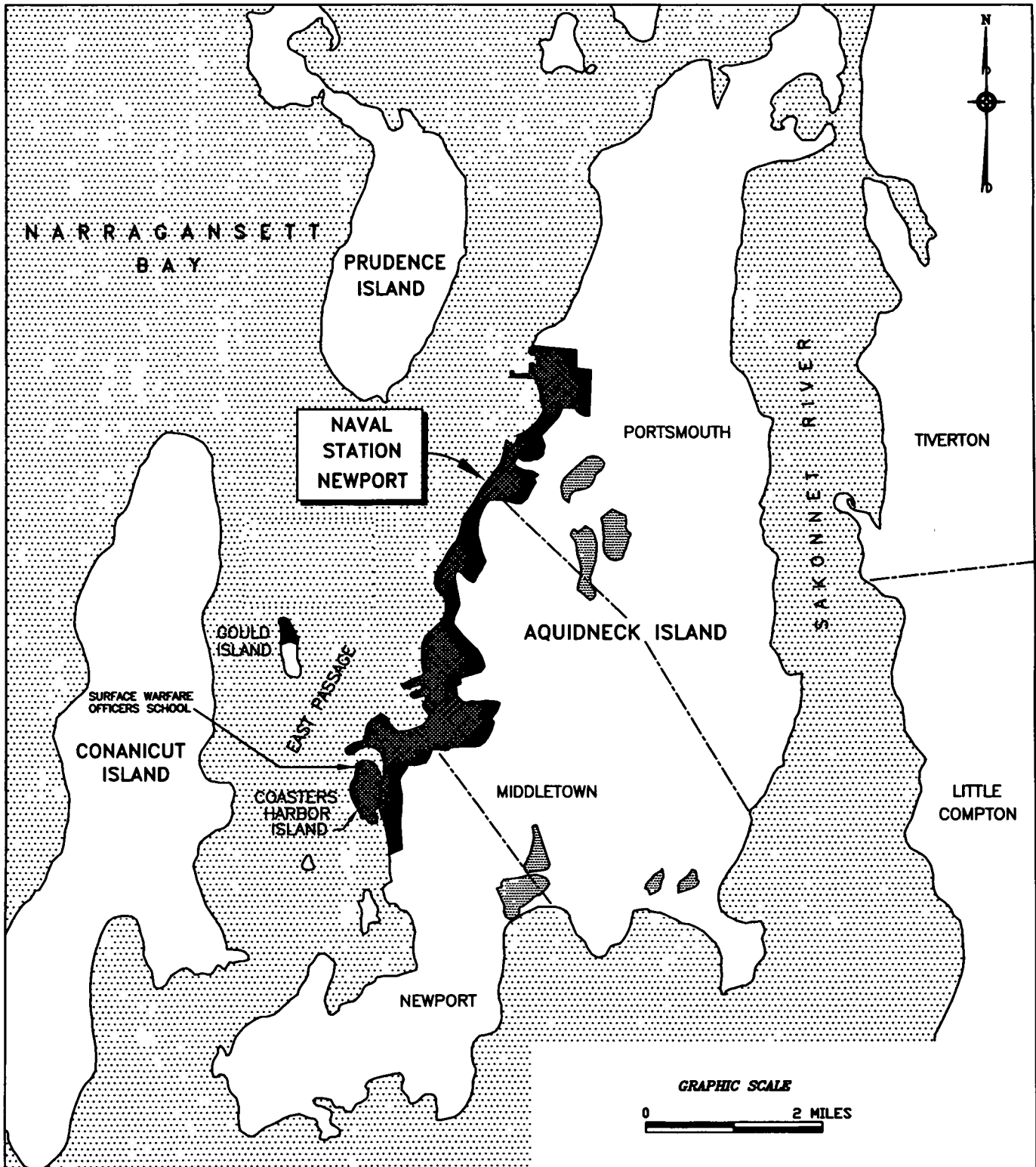
NAVSTA Newport is located approximately 25 miles south of Providence, Rhode Island. Portions of the facility are located within the City of Newport and the Towns of Middletown and Portsmouth, Rhode Island. The facility occupies approximately 1,063 acres and the layout is long and narrow, following the western shoreline of Aquidneck Island for nearly 6 miles facing the east passage of Narragansett Bay.

The Surface Warfare Officers School (SWOS) site (the site) is located on the northwestern end of Coasters Harbor Island at NAVSTA Newport. On Figure 2-1, the SWOS site is depicted in relation to the geographical extent of NAVSTA Newport. The location of the SWOS site, relative to other study areas within NAVSTA Newport, is shown on Figure 2-2. A map of Coasters Harbor Island showing the site location is provided on Figure 2-3.

As depicted on Figure 2-3, just north of the site is Taylor Drive and the Old Fire Fighting Training Area (OFFTA) site (Site 09). West of the site is Warfare Road, several buildings that make up the SWOS campus, and Narragansett Bay. South of the site is an open grass covered area, an asphalt parking lot and a number of buildings which comprise the Naval War College. The tennis courts and a gymnasium (Building 109) are located east of the site.

2.2 SITE DESCRIPTION

The site is the location of the former Brig facility at NAVSTA Newport. The building served as the correctional center (Brig facility) from its construction in 1951 until its demolition in 1996. When it was in use it was listed as Building 149 on NETC Plan No. 31490-311 prepared by Ames and Whitaker Architects (Ames and Whitaker, 1996).



SITE LOCUS

FIGURE 2-1

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT – NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	JANUARY 12, 2005
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0442\FIG_2-1.DWG

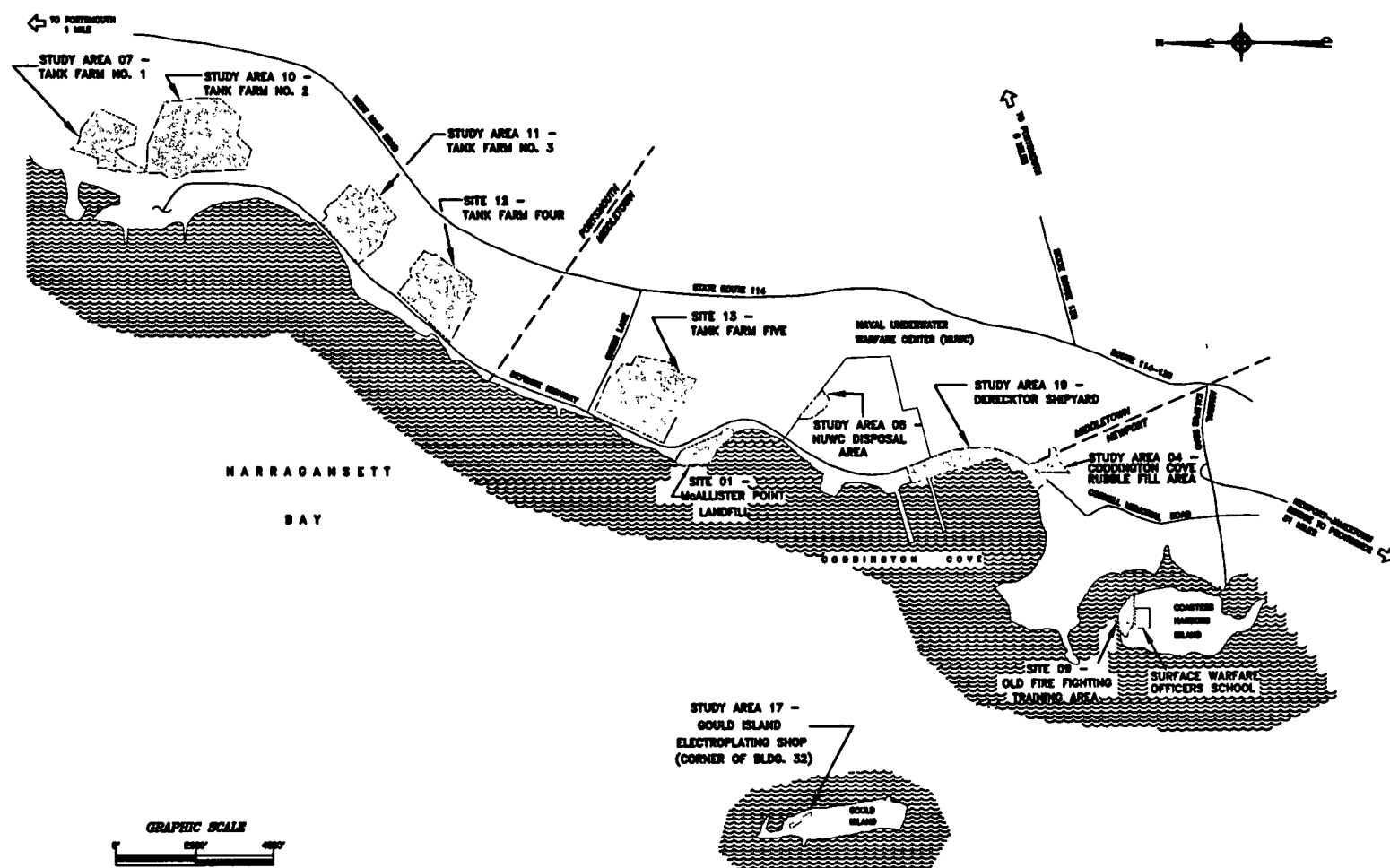



TETRA TECH NUS, INC.

55 Jonspin Road

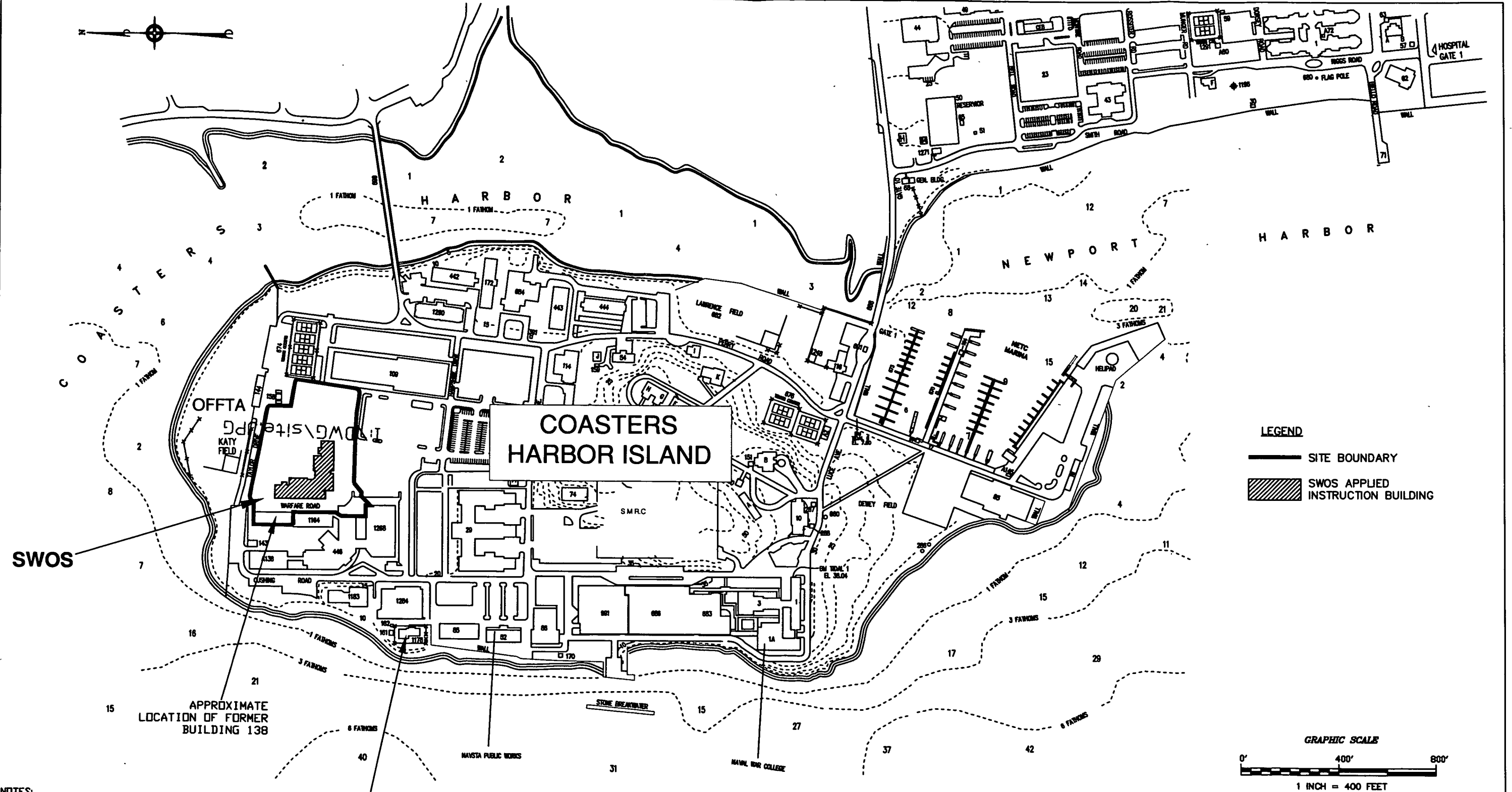
Wilmington, MA 01887

(978)658-7899



NAVSTA NEWPORT SITES AND STUDY AREAS			FIGURE 2-2	
SURFACE WARFARE OFFICERS SCHOOL			 TETRA TECH NUS, INC.	
NAVSTA NEWPORT - NEWPORT, RHODE ISLAND				
DRAWN BY:	D.W. MACDOUGALL	REV.:	0	
CHECKED BY:	L. SEYDEWITZ	DATE:	JANUARY 12, 2005	
SCALE:	AS NOTED	FILE NO.:	DWG\5152\0442\FIG_2-2.DWG	
			55 Jonspin Road Wilmington, MA 01887 (978)658-7899	

DRAFT FINAL



NOTES:

1. BASE MAP FROM PLAN BY DEPT. OF NAVY, "COASTERS HARBOR ISLAND AND NAVAL HOSPITAL EXISTING CONDITIONS MAP", DATED: 9/98, NETC DWG NO. 31058-307, CODE ID NO. 80091, SCALE: 1"=200'.

2. APPROXIMATE LOCATIONS OF FORMER BUILDING 84 AND TRANSFORMER VAULT AND BUILDING 138 FROM NETC DWG NO. 11169-118, DATED DECEMBER 21, 1951.

APPROXIMATE LOCATION OF FORMER BUILDING 84 AND TRANSFORMER VAULT

NARRAGANSETT BAY

SWOS LOCATION MAP

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	JANUARY 18, 2005
SCALE:	AS NOTED	FILE NO.:	DWG\5152\0442\FIG_2-3.DWG

FIGURE 2-3



TETRA TECH NUS, INC.

55 Jonspin Road
(978)658-7899
Wilmington, MA 01887

The site occupies approximately 90,000 square feet. The majority of the site is currently covered either by the SWOS Applied Instruction Building or asphalt paved parking. The SWOS Applied Instruction Building was constructed on site in 2003 and presently occupies an estimated 28,600 square feet, in the southwest corner of the site, adjacent to Warfare Road. Asphalt paved parking areas border the building to the north and east.

2.3 PREVIOUS SITE INVESTIGATIONS AND HISTORY

To date a limited investigation of the site has occurred. A Phase I Environmental Site Assessment for the SWOS Building Site was conducted in July 2001 (TtNUS, 2001). The Brig facility, referred to as the Correctional Center was previously located on the site as identified in the Final Initial Assessment Study (IAS) report (Envirodyne, 1983). The site was not reviewed under the IAS.

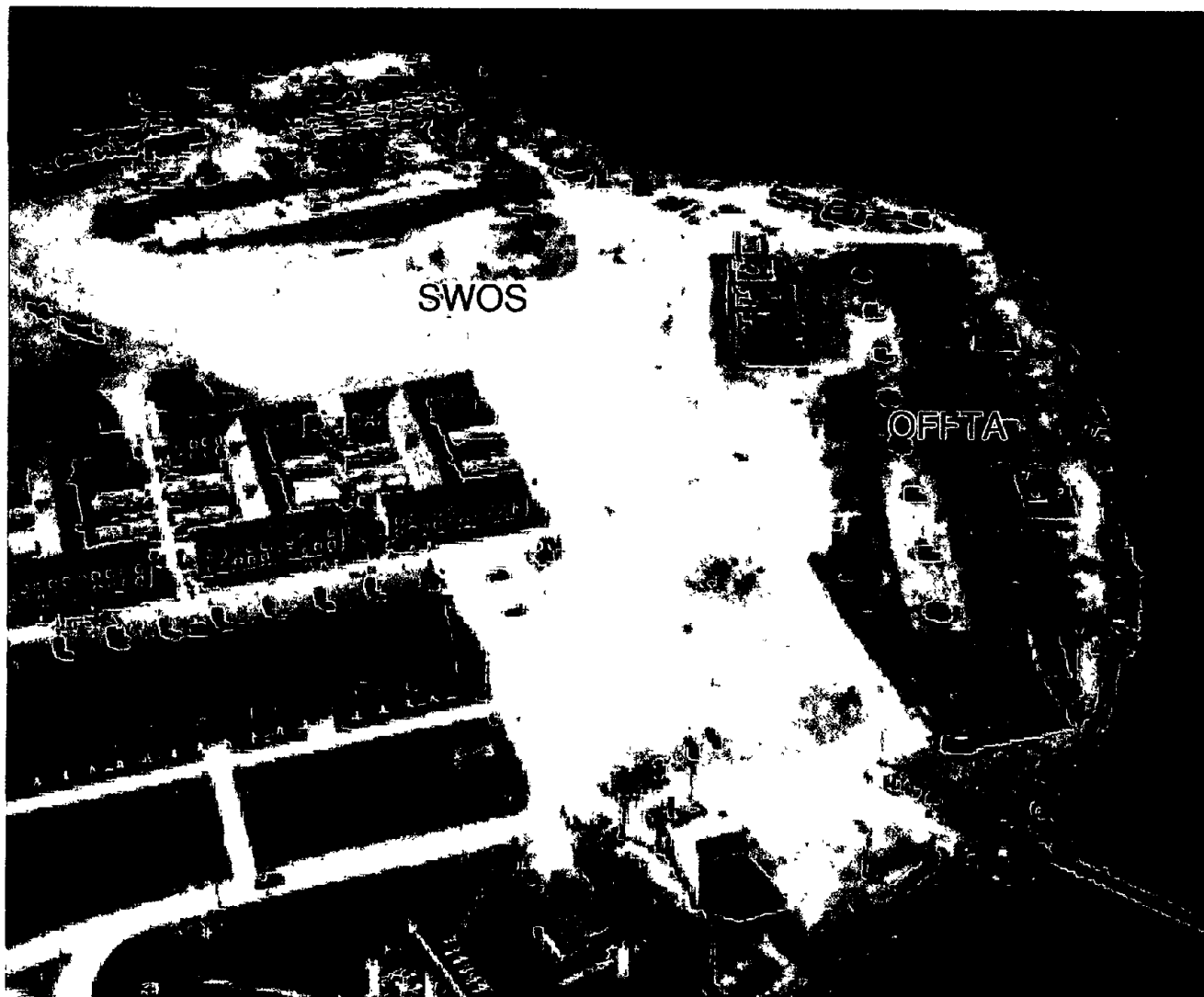
Aerial photographs of the site dating from 1944, 1951, 1962, 1992, 1996 and 1997 were reviewed. Figures 2-4, 2-5 and 2-6 present aerial photographs of the site in 1944, 1962 and 1996, respectively. The following is a summary of site observations obtained from the review of the aerial photographs.

The 1944 aerial photographs do not indicate evidence of activity in the vicinity of the site. The site is an open, partially grassy area with no trees or shrubbery present. The adjacent properties are developed and the roads are not paved.

Architectural plans show a facility, the Brig facility built in 1951 (TtNUS, 2001). As of October 1951 the facility was not present in the aerial photograph. The site was a vacant lot but shadowed areas adjacent to Warfare Road may indicate construction activity.

The facility is present in the 1962 photograph. The building takes up the majority of the site area. A paved parking lot is located directly east and another directly south of the building. Buildings border the site to the southeast and west. Structures are present at the OFFTA, north of the SWOS site.

The 1992 and 1996 aerial photographs do not indicate any significant change to the development of the SWOS site. The Brig facility is present. New building structures, parking lots and grassy areas adjacent to the site that were not present in the 1962 photograph are present in each of the 1992 and 1996 photographs. A new facility (Building 1164 and Building 446) and a paved parking lot border the site to the west. A paved parking lot borders the site to the south. A grass area borders the site to the east and according to the 1996 aerial photograph, the main structures at OFFTA have been removed and the site developed into a recreational area.

SOURCE:

NS NEWPORT NEWPORT, RHODE ISLAND, RELEASE 4.1, JANUARY 2004

AERIAL PHOTOGRAPH - 1944

FIGURE 2-4

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT - NEWPORT, RHODE ISLAND



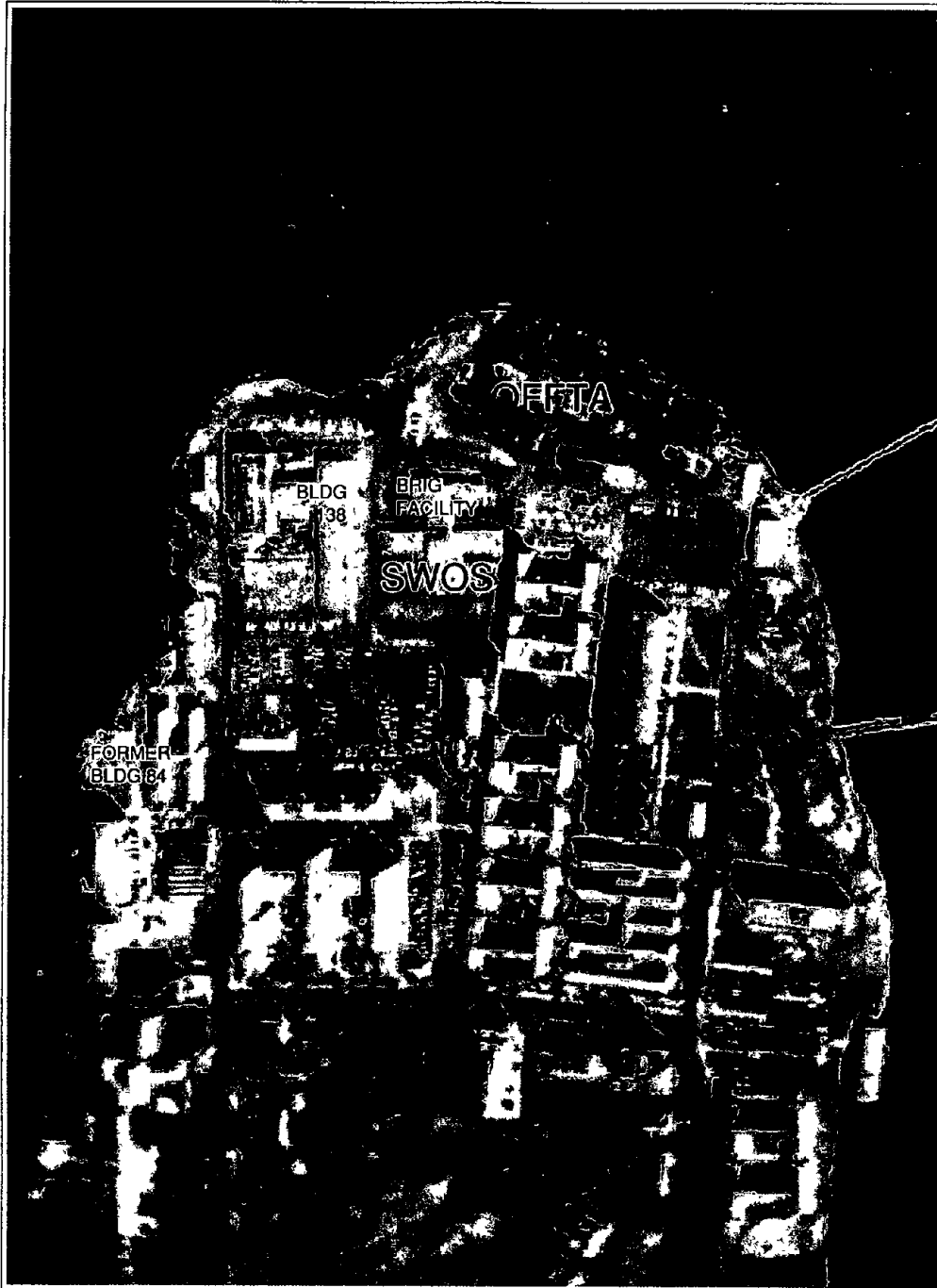
TETRA TECH NUS, INC.

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CHECKED BY:	L. SEYDEWITZ	DATE:	JANUARY 12, 2005
SCALE:	NONE	ACAD NAME:	DWG\5152\0442\FIG_2-4.DWG

55 Jonspin Road

Wilmington, MA 01887

(978)658-7899

SOURCE:

NS NEWPORT NEWPORT, RHODE ISLAND, RELEASE 4.1, JANUARY 2004

AERIAL PHOTOGRAPH - 1962

FIGURE 2-5

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	JANUARY 12, 2005
SCALE:	NONE	ACAD NAME:	DWG\5152\0442\FIG_2-5.DWG

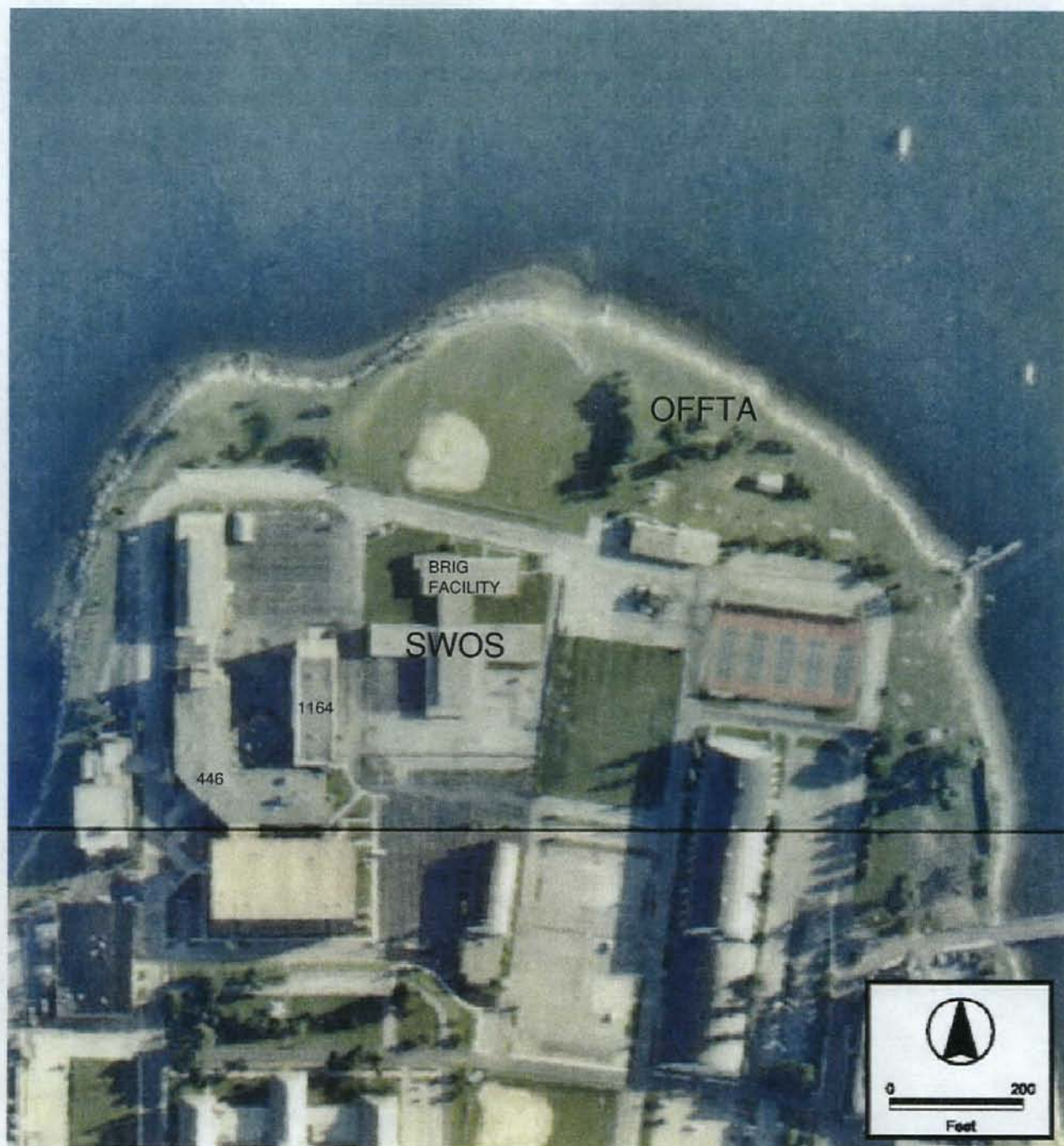


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55 Jonspin Road

Wilmington, MA 01887

(978)658-7899

SOURCE:

NS NEWPORT NEWPORT, RHODE ISLAND, RELEASE 4.1, JANUARY 2004

AERIAL PHOTOGRAPH - 1996

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	JANUARY 12, 2005
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0442\FIG_2-6.DWG

FIGURE 2-6



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(978)658-7899

W5204306DF

2-8

CTO 842

The Brig facility is no longer present in the 1997 aerial photograph. The lot is undeveloped and appears to have been leveled. There is no evidence of grass or other vegetation.

In summary, aerial photography confirms that prior to 1951, the site was undeveloped. Until its demolition in 1996/1997, the Brig facility was the primary structure on the site. Activities on the site appear to have been limited to the facility, and no connection to contamination at the OFFTA site was evident in the aerial photographs. The development of surrounding areas to the SWOS site are evident. Historic observations do not indicate evidence of activities that may have caused potential site contamination. Current site conditions are not represented in an available aerial photograph.

2.4 GEOLOGY AND HYDROGEOLOGY

This section presents a summary of the regional and site geologic and hydrogeologic features. This information is based on data from previously published literature and reports of other contractors.

2.4.1 Regional Geology

The NAVSTA Newport site is located at the southeastern end of the Narragansett Basin. The rocks of the Narragansett Basin are non-marine sedimentary rocks of Pennsylvanian age. The bedrock at the NAVSTA Newport facility is almost entirely of the Rhode Island Formation. A few areas of thick conglomerates are present within the Rhode Island Formation. They consist of pebbles, cobbles, and boulders interbedded with sandstone and graywacke. Coasters Harbor Island (Figure 2-3) is mostly covered with this conglomerate material. Overlying the Pennsylvanian rocks of the Narragansett Basin are surficial deposits of Pleistocene sediments. These unconsolidated, glacial sediments range in thickness from 1 to 150 feet and consist of till, sand, gravel, and silt.

2.4.2 Regional Hydrogeology

Many areas on Aquidneck Island, on which the NAVSTA Newport is located, obtain potable water from wells. Groundwater is obtained from the unconsolidated glacial till and outwash deposits, and from the underlying Pennsylvanian bedrock. The average depth to groundwater is 14 feet. In the NAVSTA Newport area, glacial till deposits are typically less than 20 feet thick. Well yields in these materials range from 1 to 120 gallons per minute. Although till is considered an unconsolidated deposit, the upper limit of this well yield is likely from an outwash deposit that is well sorted and stratified. Till wells typically yield a few hundred gallons of water per day, or less than 1 gallon per minute. Bedrock well yields range from less than 1 to as much as 55 gallons per minute and are highly dependent on the presence of joints

and fractures. Most groundwater is soft or moderately hard. In scattered locations, pumping has led to salt water intrusion.

In the vicinity of NAVSTA Newport, groundwater flows generally from east to west, toward Narragansett Bay. The average depth to groundwater ranges between five and twenty feet below ground surface.

Area Water Use

Public water in the City of Newport and the town of Middletown is supplied and managed by the Newport Water Department. The Town of Portsmouth purchases water from the Newport Water Department, but operates its own distribution system. Approximately two-thirds of Portsmouth is serviced by public water while the remaining one-third is supplied by water from private wells. The majority of private wells are reportedly located on the eastern portion of Aquidneck Island.

The Newport Water Department receives its water supply from a series of seven surface water reservoirs located on Aquidneck Island and two surface water reservoirs on the mainland. Each of the reservoirs is supplied water via rainfall and runoff and is not augmented by groundwater supply wells. No surface water reservoirs are located on or downgradient from the site.

Groundwater Classification

RIDEM has classified groundwater in Rhode Island to protect and restore the quality of the State's groundwater resources for use as drinking water and other beneficial uses, and to assure protection of public health and welfare, and the environment. The groundwater at the site is classified by RIDEM as GB. Groundwater classified as GB is not suitable for use as a current or potential source of drinking water, as described in the Rhode Island Rules and Regulations for Groundwater Quality (RIDEM, 1996).

2.4.3 Site Geology and Hydrogeology

In preparation for the construction of the Brig facility, five pre-construction borings were advanced in 1951 at various locations at the site. The site's surficial geology reportedly consists of stratified layers of sand and gravel fill, "hard sand and gravel", "hard cemented sand and gravel", and shale. The thickness of the overburden deposits range from about 6 to 26 feet thick. The depth to groundwater ranges from approximately 4 to 6 feet below ground surface (NETC No. 11169-118, Cull and Robinson, 1951).

Based on geologic and hydrogeologic information attained during recent investigations at the OFFTA site, located directly north of SWOS, unconsolidated materials on the site are anticipated to consist of fill,

including construction debris and sand and gravel; silty sand and gravel; sand and gravel; peat and silt; and glacial till, consisting of mixtures of silt, sand, and gravel (TtNUS, 2002).

The bedrock in this area of Coasters Harbor Island has been mapped and described as Purgatory Conglomerate. The bedrock may contain localized units of sandstone. In addition, the conglomerate is believed to be in contact with the Rhode Island Formation. In the southern portion of the Narragansett Basin, such as in the vicinity of NAVSTA Newport, the Rhode Island Formation is metamorphosed and consists of metaconglomerates and metasandstones, as well as schist, carbonaceous schist, phyllite, and graphite (TtNUS, 2002).

Groundwater elevations measured at OFFTA indicate that the groundwater flows toward Narragansett Bay and Coasters Harbor located north - northwest and east - northeast of the site, respectively (TtNUS, 2002). The proximity of SWOS to the OFFTA site may suggest that groundwater flow would be similar. The depth to groundwater ranges from 4 to 6 feet below ground surface (bgs) (NETC No. 11169-118, Cull and Robinson, 1951).

2.5 SITE WASTE CHARACTERISTICS

The Phase I Environmental Site Assessment (TtNUS, 2001) identified a number of potential hazardous waste sources on the site. The presence of transformers historically known to be sources of polychlorinated biphenyl (PCB) contamination, light ballasts containing PCBs, lead-based paint and asbestos-containing materials (ACM) have been located in the vicinity of the SWOS site. However, a review of records and a site reconnaissance suggest that these should not be considered a source of contamination. Light ballasts, lead-based paint, and ACM were all part of the Brig building which has been demolished, and the debris cleared from the site. The transformers identified in the Phase I ESA are not located within current site boundaries and will not be addressed as part of this Focused SI.

During soil excavation to install subsurface utility lines in support of the construction of the SWOS Applied Instruction Building, oily soils were discovered in areas adjacent to Taylor Drive. The type of oil found is unknown. Soil sampling was conducted in May and July 2003 and a risk assessment performed to determine construction worker exposure risks during utility line installation and asphalt parking lot construction. All samples were analyzed for Target Analyte List (TAL) metals and Target Compound List (TCL) constituents: volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, and PCBs. The analytical results were compared to RIDEM Industrial/Commercial (I/C) Direct Exposure Criteria. One sample contained a lead concentration that exceeded the RIDEM I/C Criteria of 500 ppm and three samples contained total petroleum hydrocarbon (TPH) concentrations that exceeded the RIDEM I/C Criteria of 2,500 ppm. The risk assessment calculated the construction worker hazard

index (HI) to be 0.033, which is below the USEPA's Threshold HI of 1.0 and, therefore, is unlikely to be associated with adverse health effects (Foster Wheeler Environmental Corporation, 2003). Previous test pit and soil sample locations are shown on Figure 2-7. A copy of the Final Report and Risk Assessment for Worker Exposure at the SWOS site can be found in Appendix D of this work plan.

There are no records indicating that underground storage tanks (USTs) or above ground storage tanks (ASTs) were present at the former Brig facility or of Oil and Hazardous Material (OHM) storage at the facility. The former Brig facility was connected to the station sewer system (TtNUS, 2001). There is no identified septic waste disposal or hazardous material disposal area on the property (TtNUS, 2001).

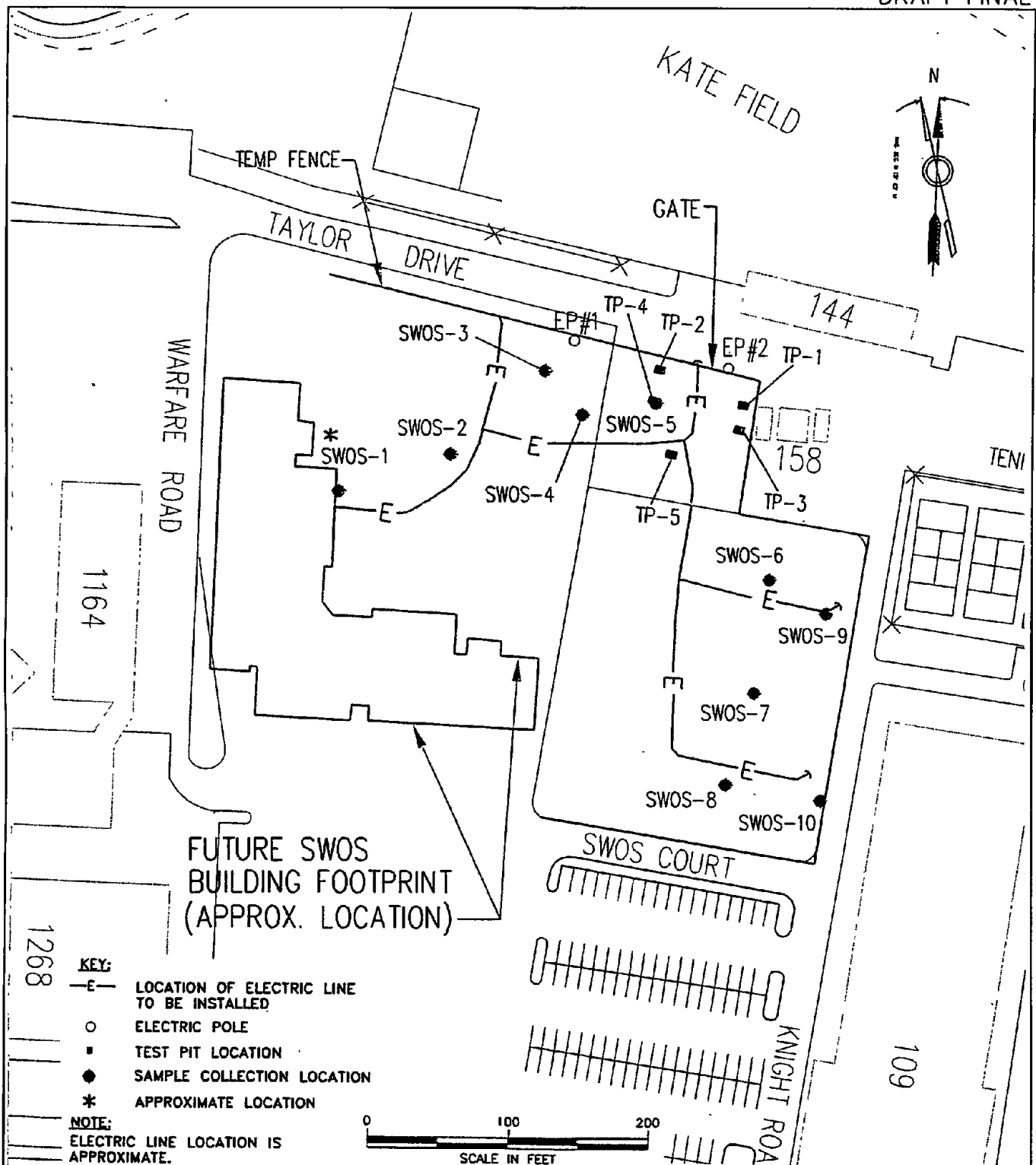
2.5.1 Potential Off-Site Contamination Sources

There are several potential off-site contamination sources that may represent a threat of contamination to the site. The OFFTA site may represent a significant threat of contamination to the site due to the proximity and nature of contamination located there. A Remedial Investigation/Feasibility Study has been conducted at the OFFTA site (Site 09), located directly north of Taylor Drive and the SWOS site (see Figure 2-3). Analytical results presented in the Feasibility Study for the OFFTA site indicate that SVOCs, metals and one pesticide exceeded RIDEM Residential Direct Exposure Criteria for soil. For groundwater, one metal and one VOC exceeded the drinking water criteria at the site (TtNUS 2002).

Elevated arsenic concentrations are present at the OFFTA site. A Background Soil Investigation conducted for the OFFTA site states that the calculated background concentrations of arsenic at Coasters Harbor Island are believed to be attributable to the composition of the local and regional bedrock formations and the shallow depth to bedrock in the area (TtNUS, 2000). The potential presence of elevated arsenic in the surface and subsurface soils at the SWOS site would likely be attributed to natural background conditions since there has been no history of releases involving arsenic.

Structure 74, was a double chamber tank, presumed to have contained heating oil, located approximately 1,000 feet south of the SWOS site, along the west coast of Coasters Harbor Island (see Figure 2-3). The type of heating oil has not been identified. Historically, Structure 74 has been identified as a contamination source (RAB, 1999). There was a pump and treat system in place at the structure until the removal of both the building and the structure in 2002 (RAB, 1999). Groundwater from Structure 74 is assumed to flow directly to Narragansett Bay, making it unlikely that any contaminated groundwater from Structure 74 would migrate to the SWOS site. The tank has been cleaned and filled with foam, and the contamination remediated (TtNUS, 2001).

A District Public Works Office map dated December 1951, and titled "Pilot Plan and Location Plan: 75 Man Brig" (NETC No. 11169-118; Cull and Robinson, 1951), depicts two potential sources of



2003 TEST PITTING AND SOIL SAMPLING LOCATIONS

FIGURE 2-7

SURFACE WARFARE OFFICERS SCHOOL

NAVSTA NEWPORT — NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	D. CHISHOLM	DATE:	JANUARY 18, 2005
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0442\FIG_2-7.DWG



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contamination in the vicinity of the Brig facility. A transformer vault, labeled Building 84, was located approximately 800 feet southwest and hydrologically upgradient of the site. An area labeled "fuel tanks" was located approximately 400 feet directly west of the south corner of the Brig building, behind Building 138 (see Figures 2-3 and 2-5 for approximate locations). A review of available information did not reveal the types of petroleum products that were stored in this area. Recent maps do not depict either of these structures, indicating that they may have been closed and no longer exist (NETC No. 31491-311; Ames and Whitaker, 1996).

2.6 DATA QUALITY OBJECTIVES

The data quality objectives (DQOs) for this project were developed in accordance with the EPA Guidance for Data Quality Objectives (EPA G4 document). The G4 document suggests seven steps be followed to develop project DQOs. The objectives are somewhat previously established by CERCLA guidance, the Federal Facilities Agreement, and other standard guidelines for the performance of Focused SI's. The intended use of the data resulting from a field investigation is a determining factor in defining the DQO for that data. To be certain that the data is consistent with the goals of the investigation, the seven steps of defining DQOs is suggested.

The seven steps are described in the following subsections:

2.6.1 Statement of the Problem

During construction of the SWOS building at NAVSTA Newport, oil was encountered in the ground at concentrations exceeding RIDEM criteria. Other contaminants may exist, as there is little record of historical activities at this site.

The investigation will identify contaminants present on the SWOS site and whether those contaminants represent a threat of contamination to the soil and groundwater proximal to the site. The possible relationship of the SWOS site to the adjacent OFFTA site will be discussed, based on the data collected, and data assessment will be performed. The findings of this Focused SI will determine if subsequent investigations are necessary and the extent thereof.

2.6.2 Identification of the Decision

After the completion of this study, a decision will be made as to whether there will be a need for additional studies and actions under the CERCLA process. This decision will be based on any exceedances of concentrations of CERCLA hazardous substances above regulatory criteria and whether

those exceedances are a result of activities at the OFFTA site. Non CERCLA contaminants (TPH) will be evaluated against applicable criteria for other regulatory actions. If the data assessment determines that the contaminant exceedances are a result of the OFFTA site, those contaminants will be addressed through OFFTA remedial actions. If the data assessment determines that the contaminant exceedances are a result of some other release, additional steps in the CERCLA process will be followed. If results of the data assessment determine that regulatory criteria are not exceeded, no further action will be required for the site.

2.6.3 Inputs to the Decision

Inputs to the decision are the elements used in the decision process. Inputs to the decision as stated in Section 2.6.2 are as follows:

- Concentrations of the contaminants present
- USEPA and RIDEM recommended standards for determining adverse exposure

2.6.4 Definition of the Study Boundaries

Study boundaries can be physical and temporal. This section defines the boundaries and the rationale for their selection.

The problem stated in Section 2.6.1 focuses on the entire SWOS site. Although other contaminant sources may be present upgradient or adjacent to the site that may result in the deposition of contaminants at the site, the study shall remain focused on the identification of and concentrations of contaminants within the site. The study will evaluate the soil and groundwater at the site.

Temporal boundaries will be limited to the current contaminant concentrations as compared to criteria. The exposure and potentially associated risk as evaluated from contaminants now present will be accounted for, pending the data assessment. In addition, the potential for future exposure pathways and risk may be evaluated.

If necessary, detailed exposure scenarios for the current and future use will be residential. Access to the property is currently only available to NAVSTA Newport employees and SWOS students.

During the field investigations, the field personnel on site will note the use of the site by any persons other than NAVSTA Newport employees or SWOS students who are designated to be in the area.

2.6.5 Decision Rule

The decision rule is a clear statement defining the requirements of the investigation based on the possible outcomes of the study. For this work plan, the decision rule shall be as follows:

- If the data assessment indicates that contaminants are present above regulatory criteria as a result of releases at the OFFTA site, those contaminants may be addressed through OFFTA remedial actions in progress.
- If the data assessment indicates contaminants present above regulatory criteria as a result of some release other than that which occurred at OFFTA, it will be addressed on a regulatory track separate from OFFTA.

2.6.6 Limits on Decision Errors

The limits of decision errors are set to quantify the potential for false negative and false positive decisions. As a Focused SI, this study requires a low potential for a false negative decision. This means deciding not to go forward with CERCLA actions when in fact the risk defined in the Decision Rule does exist and actions should be taken. Conversely, a somewhat higher tolerance for a false positive decision is acceptable for this stage, since the resulting effect would be to carry the process as far as the feasibility study when it is not warranted. A separate decision rule would be set for a cleanup action as a part of the Record of Decision (ROD).

Conservatism in the process for the assessment of risks will decrease the potential for a false negative decision but not overly increase potential for a false positive decision. This conservatism is applied with exposure scenarios and other parameters used to measure exposure. This conservatism is furthered by evaluating the reasonable worst-case scenario for exposure using the maximum concentrations detected. Average concentrations are also used in the risk assessments in order to have some manner of comparison.

2.6.7 Design for Obtaining Data

The DQO process described in the G4 DQO document describes the use of various statistical approaches for development of a database. These are typically based on the representativeness of the data that are required. For instance, if the Decision Rule was to "remove soils with concentrations of lead above 10 mg/kg", the sampling plan would be based on the capability for identification of hot spots of a predetermined size, which would be the basis for precision on the removal action to be taken.

However, given the goals of this investigation, the design of the sampling plan can be more qualitative. The sampling plan is provided in Section 3 of this work plan. Samples will be collected to measure concentrations of contaminants present to which human receptors may be exposed.

Sample media for this site will include surface soils, subsurface soils, and groundwater at and near the areas of suspected impact. This approach will allow the investigators to determine the "extent of contamination" if a remedial investigation is required under CERCLA. Samples will be analyzed for target analytes (petroleum and petroleum-related contaminants), but also for a full analytical suite of pollutants to ensure a complete data set in case further evaluations (risk assessment) are found to be necessary in the future.

Specifics on the precision, accuracy, representativeness, etc. of the data collected are described in the Quality Assurance Project Plan, presented in Section 4 of this work plan. These are established standards for Remedial Investigations under the CERCLA process. Use of these standards will allow the use of the data collected as a part of this study in a Remedial Investigation if one is required at a later date.

3.0 FIELD INVESTIGATION AND SAMPLING PLAN

The following sections detail the field activities to be performed during this investigation. Specific TtNUS Standard Operating Procedures (SOPs) will be referenced where applicable. The analytical laboratory has not been identified at this time. Once selected, laboratory SOPs will be maintained as part of the administrative record.

3.1 INTRODUCTION

The focus of the Field Sampling Plan (FSP) is to assess and evaluate site conditions in order to obtain adequate data to support the Focused SI report and the data assessment. The objectives are to:

- Characterize the waste materials that may exist at the SWOS site and determine the preliminary extent of hazardous materials released to the environment.
- Determine the type of contamination associated with releases (if any) from the use and subsequent demolition of the Brig facility.
- Identify contaminants that may exist on site.
- Collect samples for full TCL organics (including VOCs, SVOCs, and pesticides/PCBs), gas range organics/diesel range organics (GRO/DRO), TAL total and dissolved metals analyses to support the data needs of the data assessment.

The data collected during these investigations must be capable of supporting these assessments. The content of the report and the assessments is described in Section 5.0 of this work plan.

The field investigation will consist of three tasks including: 1) a reconnaissance survey and records search, 2) a geologic/hydrogeologic investigation and environmental sampling, and 3) a land survey. The details of each task are described in the following sections.

3.2 TASK 1: RECONNAISSANCE SURVEY AND RECORDS SEARCH

Access to the study area is restricted. The NAVSTA Newport facility, including the SWOS site, is completely fenced and guarded. Prior to any on-site work activities, security passes will be required for all TtNUS and subcontractor personnel while working in the study area. Security passes will be obtained through coordination with NAVSTA Newport contacts.

A site walkover will be conducted by the TtNUS field sampling team members to familiarize themselves with site conditions. The site will be reviewed with respect to access restrictions and sampling locations. Site-specific health and safety considerations, including emergency evacuation procedures, will be reviewed. Pertinent features, such as any overhead and subsurface utilities, and other potential hazards will be reviewed with Navy personnel with respect to planned sampling activities.

In addition to the planned field activities, a new records search will be conducted for documentation of the planned removals and abatement which occurred before and after the demolition of the Brig facility. The records search will include a search and review of RIDEM, Navy, and TtNUS data sources. An attempt will also be made to locate and interview naval personnel at the base who may have been associated with prior activities at the site.

3.3 TASK 2: GEOLOGIC/HYDROGEOLOGIC INVESTIGATION AND ENVIRONMENTAL SAMPLING

The objective of this task is to evaluate the presence of soil and groundwater contamination resulting from historical on-site or potentially off-site activities. Chemical data will be collected to assist in making preliminary determinations on the presence of contaminants in the two media. The data will then be assessed by comparing results to criteria.

The scope of work for the geologic/hydrogeologic and sampling investigation includes the following specific components:

- Characterization of a possible water table aquifer.
- Initial characterization of overburden soils and bedrock.
- Collection and evaluation of groundwater quality data at background locations.
- Assessment of the nature and distribution of groundwater contamination at the site.
- Additional characterization of contaminant migration pathways, including presence of permeable soils and features associated with surface water runoff, such as underground drainage systems.

The subsurface exploration program will address the areas of concern identified in the Phase I Environmental Site Assessment (TtNUS, 2001) and more recently, the Final Report and Risk Assessment for Worker Exposure at the SWOS Site (Foster Wheeler Environmental Corporation, 2002). Specifically, the sampling program will be expanded to adequately characterize areas of contamination encountered during the construction of the SWOS Applied Instruction Building. One background boring and one background micro well will also be installed as a part of this investigation. Proposed boring/micro well locations are presented on Figure 3-1 of this work plan. The proposed field samples are presented on Table 3-1.

Twenty test borings are planned in the study area to investigate potential releases of contamination to soils, characterize subsurface lithology, and for the installation of five micro wells (UW01 through UW05, Table 3-2). Table 3-2 describes the location, the proposed screen interval, and the purpose of each of the wells to be installed. An effort will be made to locate borings in unlandscaped areas (pavement) as well as away from new structures.

The planned soil boring locations may be reassessed based upon any observed evidence of gross contamination or staining which could indicate the presence of high concentrations of contaminants that may be leaching into the groundwater. If drums or other evidence of gross contamination are discovered, the wells may be moved and placed in the area(s) to determine partial impacts on the shallow overburden aquifer.

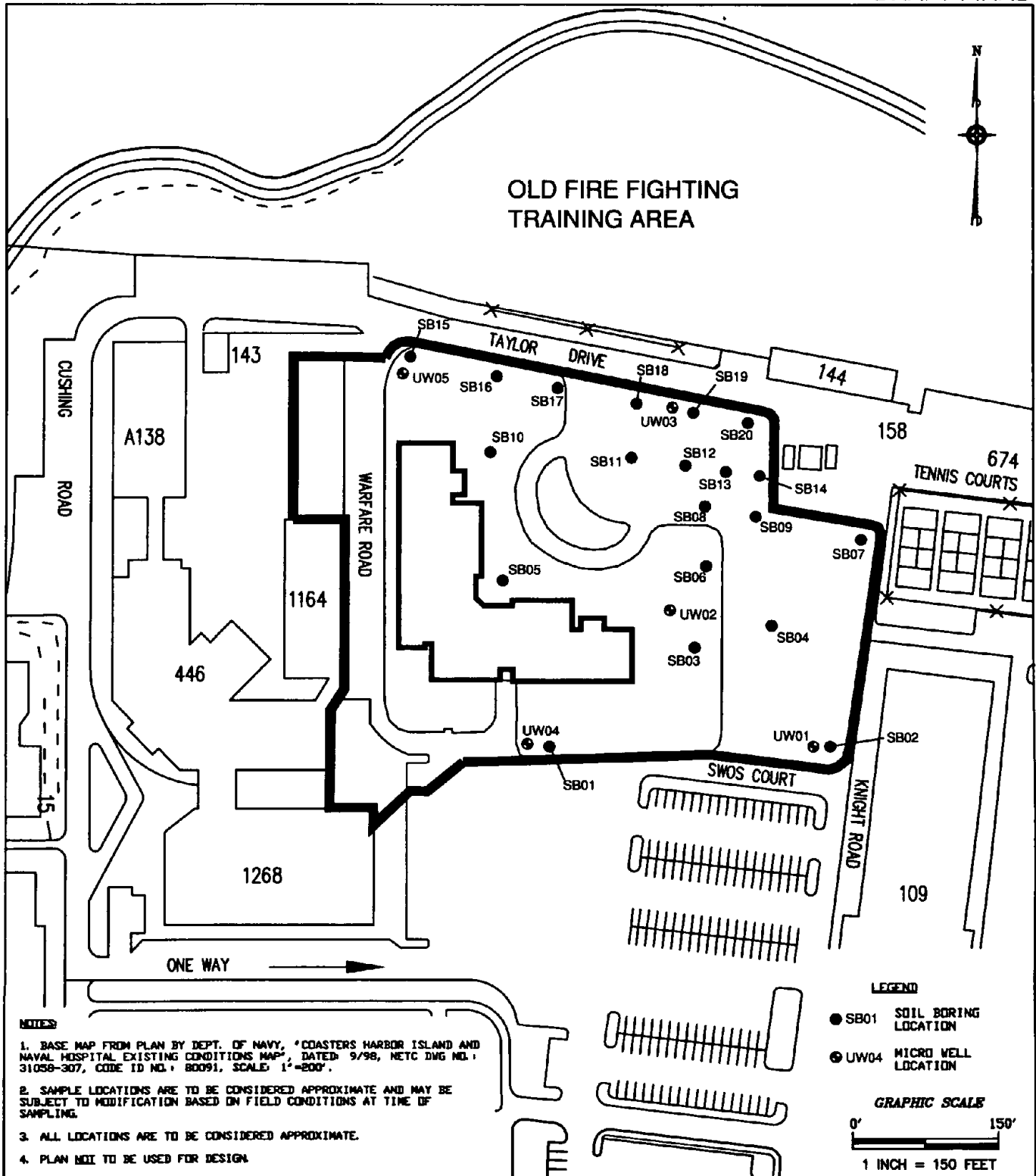
Proposed changes in the location or in the number of borings/wells will be discussed with RIDEM and EPA prior to actual field operations, and if a change is warranted, the regulatory parties shall also be notified using a Field Modification Request, as described in Section 1.5 of this work plan.

3.3.1 Advancement of Borings

A total of 20 2-inch soil borings will be advanced using Direct Push Technology (DPT). The drilling apparatus uses Macro-Core® samplers fitted with detachable aluminum or steel drive points that are driven into the ground using hydraulic pressure. The specific equipment used will be determined based on field conditions and the expected use of the borehole.

The soil borings will be advanced following general procedures specified in TtNUS SOP No. SA-2.5. Soil cores will be collected in an acetate sleeve in 2- 4-foot lengths. Soils will be described according to the Unified Soil Classification System, and logged to provide a complete lithologic record of the subsurface materials. As each acetate sleeve is opened, the soils will be monitored for organic vapors by scanning the soils using a flame ionization detector (FID) monitoring instrument and a photoionization detector (PID). The breathing zone of both the drillers and samplers will be periodically monitored for organic vapors, in accordance with the site specific Health and Safety Plan (Appendix A).

Soil borings will be advanced to 5 feet below the top of the saturated zone or to bedrock, as determined by the rig geologist. Depth to bedrock is estimated to be 8 feet below ground surface (bgs). If refusal is encountered before 8 feet bgs, up to two more attempts will be made. If bedrock is not encountered



SAMPLE LOCATIONS

FIGURE 3-1

SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND

DRAWN BY: D.W. MACDOUGALL	REV.: 0
CHECKED BY: L. SEYDEWITZ	DATE: JANUARY 18, 2005
SCALE: 1" = 150'	ACAD NAME: DWG\5152\0442\FIG_3-1.DWG



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TABLE 3-1
PROPOSED FIELD SAMPLES
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

ACTIVITY	MEDIA	NUMBER OF SAMPLES			
		TCL VOCs and Percent Moisture	TCL SVOCs ⁽¹⁾	TAL Metals	GRO/DRO (8015B Modified) ⁽³⁾
Geologic/Hydrogeologic Investigation	Soil	40	40	40	40
	Groundwater	5	5	5	5
	Total ⁽²⁾	45	45	45	45

Notes:

- ⁽¹⁾ SVOC parameters include TCL base, neutral and acid extractable compounds, pesticides, and PCBs.
- ⁽²⁾ Proposed field sample totals do not include quality control samples.
- ⁽³⁾ DRO by Method 8015 Modified for Extractable TPH, C9-C36 Hydrocarbon by G.C.

TABLE 3-2
WELL INSTALLATIONS/SOIL BORINGS
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

WELL/BORING NUMBER	LOCATION	WELL SCREEN INTERVAL	PURPOSE OF WELL
UW01 (upgradient location)	Southeast of the site in an anticipated hydrologically upgradient area and adjacent to SB02 (Refer to Figure 3-1)	Unconsolidated overburden based on field screening and soil conditions	Establish background groundwater quality in overburden.
UW02	Central portion of the site, east of the SWOS Applied Instruction Building	Unconsolidated overburden, based on field screening and soil conditions	Assess impacts of site contaminants on groundwater quality in overburden.
UW03	Northeast corner of the site, adjacent to SB19	Unconsolidated overburden, based on field screening and soil conditions	Assess contaminants present in groundwater at or immediately downgradient of area of observed contamination.
UW04	Southern extent of the site, adjacent to the south (paved) entrance area and SB01	Unconsolidated overburden, based on field screening and soil conditions	Assess impacts of contaminants on groundwater quality in overburden.
UW05	Northwest corner of the site, adjacent to SB15	Unconsolidated overburden, based on field screening and soil conditions	Assess downgradient impacts of contaminant releases on groundwater in overburden.
SB01-SB20	(Refer to Figure 3-1)	N/A	Assess impacts of site contaminants on soil quality.

within 5 feet of the water table, one boring will be advanced to bedrock. If the water table is not encountered before reaching bedrock, up to three attempts will be made to penetrate the bedrock to find the water table. If evidence of contamination exists at the bedrock overburden interface, the Navy will review the need for bedrock borings/wells.

A log of each borehole will be maintained by the field geologist to describe lithologies encountered, depth of geologic contacts, water levels, sample depths, bedrock characteristics, and any other pertinent observations made during drilling. Boring logs will also include information on sample number, type, and depth; and sample interval and recovery. An example boring log is included in Appendix C of this work plan.

Any drill cuttings will be containerized and sampled for waste characterization, as described in Section 3.9. Decontamination of sampling equipment and drilling apparatus will be performed as described in Section 3.10.

3.3.2 Soil Sampling

A total of 40 soil samples will be collected from the 20 DPT borings. The borings will be 2-inch in diameter to minimize site disruption and afford quick sample acquisition. Two soil samples will be collected from soil borings in paved areas: one from the 0 — 2-foot interval immediately below the roadbase material, and one from the 2-foot interval just above the groundwater table (soil saturation as determined in the field). In borings through pavement, the 0 – 1-foot interval will be considered below pavement and general roadbase material and will be no less than 1 foot below the surface. If signs of potential contamination (e.g., odors, stains, sludges) are observed at a depth between the two planned sampling intervals, the second sample will instead be collected from the depth of greatest observed contamination (i.e., most stained or highest headspace screening results) below the surface interval. VOC headspace screening will be performed on each sample using a FID as well as a PID. The jar headspace screening method is presented in Appendix B of this work plan. For borings advanced in unpaved areas, samples will be collected from 0 – 1 foot and 1-2 feet bgs in addition to the sample collected from the 2-foot interval just above the water table. This will ensure appropriate data are available to evaluate CERCLA exposure scenarios at the soil surface, will avoid testing only of fill that may have been brought onto the site, and will provide information for the 2-foot interval which is required for the RIDEM Site Remediation Regulations.

The sample from each interval will be treated as separate samples. Aliquots of the material for VOC and GRO analyses will initially be collected using a cut syringe or equivalent device and placed in pre-preserved vials with septa caps, according to SW846 Method 5035A, July 2002.

The following procedure should be followed:

1. Label four pre-tare weighed 40-ml amber vials containing reagent grade water with the sample location number and a bottle letter such as A, B, etc. (two for the VOC analysis and six for the VOC matrix spike/matrix spike duplicate analysis). Label two pre-tared weighed 40-ml amber vials containing methanol for the GRO and medium level concentration VOC analysis.
2. Collect approximately 5 grams of material by coring or stabbing the soil or sediment with a 10-ml pre-cut syringe. Extrude the sample into one of the 40-ml VOC vials containing 5 ml of reagent grade water or methanol. The soil must be immersed in the water or methanol; recollect the sample using a smaller volume if necessary. Avoid touching the threads on the vial's neck or loss of water by evaporation. Cap the vial and invert it several times to mix the sample.
3. Weigh the sample vial again to the nearest 0.01 g and record the weight in the field log sheet. Repeat the procedure with the other vial(s). Pack and ship to the laboratory. Include the field log sheet containing the sample weight information. One in every 20 samples should be assigned as a laboratory matrix spike/matrix spike duplicate. For this sample, collect six water preserved vials for VOC analysis.

Soil samples preserved with methanol will be shipped and maintained at 4°C until analyses within 14 days of sample collection. The soil samples preserved with VOC-free reagent water may also ship at 4°C daily to the assigned laboratory. The laboratory will either analyze the samples within 48 hours or will freeze them at -7°C and perform the VOC analysis within 14 days from sample collection.

The soil samples for GRO and VOC medium-level concentration analysis will be preserved with methanol.

Soil Sample For Percent Moisture Fill one 2-oz. container with soil or sediment from the same location that the samples for VOC analysis were collected.

Every effort should be made to collect multiple cores of soil for the water preserved and methanol preserved vials, and the percent moisture as close to one another as possible in each sample interval to obtain precise results.

Field duplicate samples will be collected from the subsurface soils. Following the collection of the first set of VOC and GRO containers, collect the field duplicate set from the same sampling interval.

Collect field duplicates and assign the matrix spike/matrix spike duplicate from different locations.

After the VOCs and GRO are collected, the remaining material in the open acetate sleeve will be placed into a decontaminated stainless steel bowl and homogenized with a decontaminated stainless steel trowel, disposable scoop, or similar device. After mixing to homogenize the sample, aliquots will be removed for analysis of TCL SVOCs, pesticides/PCBs, TAL metals, and DRO. A summary of the sampling and analytical parameters is provided in Table 3-1. The sample containers for the different analytical parameters should be filled in the following order: VOCs/GRO/percent moisture, SVOCs, DRO, pesticide/PCBs, and metals.

Samples will be designated as the soil boring designation (SB##), and depth intervals will be expressed in feet. For example, sample SWOS-S-SB05-0204 indicates a soil sample from the boring for SB05, 2 feet to 4 feet below ground surface. Details of sample designations are presented in Section 4.4 of this work plan.

Appropriate chain-of-custody procedures will be followed (see Section 4.4.2) and samples will be labeled, packaged and shipped according to TtNUS SOP No. SA-6.1. Required analytical methods, sample preservation requirements, required sample containers, and Data Quality Levels are provided in Table 3-3. Table 3-4 summarizes the quality control samples to be collected and analyzed. Decontamination of sampling equipment is summarized in Section 3.6.

3.3.3 Groundwater Monitoring Points

As part of the assessment of the nature and distribution of contaminants in groundwater, micro wells will be installed and a sampling program conducted. This program includes installation of five micro wells in addition to the 20 DPT borings. The proposed location of each well installation is presented on Figure 3-1. The purpose of each installation is presented in Table 3-2.

Four micro well locations (UW02 through UW05) have been selected to evaluate potential releases of site related contamination to groundwater. One additional location (UW01) represents a micro well installed hydraulically upgradient of the SWOS site to establish background groundwater quality conditions in the overburden.

The micro wells are planned in the following locations: one overburden well toward the southeast corner of the site in the anticipated upgradient groundwater flow direction (UW01, background), one overburden well in the central portion of the site (UW02), one overburden well in the northeast corner of the site in a vicinity immediately downgradient of the area of observed contamination (UW03), one overburden well along the southern boundary (UW04) and one overburden well in the northeast corner of the site (UW05) at a location in the anticipated downgradient flow direction of the groundwater.

Additional groundwater micro wells beyond those already scoped in this work plan will be installed if deemed necessary for this Focused SI by agreement between the Navy and all the regulatory oversight parties.

3.3.3.1 Groundwater Monitoring Well Screen Installation

The depth of the well screen installation will be determined in the field based on conditions that may include: depth to groundwater, vertical zones that are more or less permeable to water than others, soil types present, headspace screening results, visual evidence of contamination (and an absence of field instrument response to headspace screening), the presence of multiple horizons of contaminants, and depth to bedrock.

Table 3-2 describes the location, the expected screened interval, and the purpose of each of the micro wells to be installed.

Well screens and sandpacks used for the overburden well installations will be sized in accordance with the geologic formation at each boring location. Well screens with slot sizes of 0.010 (0.25 mm) and 0.020 (0.5mm) will be available at the site. Filter pack sizes of 20-40 (0.85 mm - 0.425 mm) and 10-20 (2.0mm - 0.85 mm) sieve size sand will be available for installation with each respective screen aperture.

Screen aperture size and filter pack will be selected based on a visual inspection of the split barrel soil samples collected from the screened interval. The field geologist/engineer will classify the soil sample, and visually estimate the quantity of the coarse sand fraction present in the interval to be screened. If coarse sand (defined in ASTM D 2487-92 as ranging in size from 2 mm to 4.75 mm diameter) represents a minimum of 70% by weight of the mass, a 0.020 slot screen and 10-20 sieve size filter pack will be installed. If coarse sand represents less than 70% of the screened interval, a 0.010 slot screen and 20-40 sieve size filter pack will be installed.

However, if the screen interval is highly stratified, containing lenses of silty soils, a 0.010 slot screen and 20-40 sieve size filter pack will be installed to minimize siltation of the well.

The well screens will be installed in the saturated zones, if possible, across the interval that shows the highest level of contamination. However, if conditions warrant it (i.e., if contaminants detected by headspace screening indicate the presence of a light non-aqueous phase liquid [LNAPL]), screens may be placed across the water table to sample the LNAPL. Such changes to the work plan will be documented to the regulatory parties in Field Modifications Requests as described in Section 1.5 of this work plan.

TABLE 3-3
SAMPLE CONTAINER, PRESERVATIVE, AND HOLDING TIME REQUIREMENTS
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

SAMPLE MEDIUM	ANALYSIS	SAMPLE CONTAINER	PRESERVATIVE	HOLDING TIME	USEPA/ NFESCDQO LEVEL ⁽¹⁾
Soils	TCL VOCs (SW 846 5035A, 8260B)	2-40 ml VOC vials	5 mls reagent grade water*, freeze -7°C Cool to 4°C	14 Days (Analysis)	IV
	GRO (SW846 5035A/8015B modified)	2-40 ml VOC vials	5 ml methanol Cool to 4°C	14 Days (Analysis)	IV
	TCL SVOCs (SW846 8270C) TCL PCBs/Pesticides (SW846 8081, 8082)	8 oz wide mouth jar	Cool to 4°C	7 Days (Extraction) 40 Days to analysis	IV
	TAL Metals (SW846, 6010B, 7471A)	4 oz wide mouth jar	Cool to 4°C	Hg 28 Days, Others 6 months	IV
	DRO (SW846 8015B modified)	8 oz wide mouth jar	Cool to 4°C	28 days	III
	Percent Moisture	2-oz glass jar	Cool to 4°C	14 days analysis	III
Groundwater	TCL VOCs (SW846, 8260B)	2 - 40 ml VOC vials	HCl to pH <2/Cool to 4°C	14 Days (Analysis) 7 Days (Extraction)	IV
	TCL SVOCs (SW846-8270) TCL PCBs/Pesticides (SW846, 8081 8082)	2-80 oz amber bottle	Cool to 4°C	7 Days (Extraction)and 40 days analysis	IV
	TAL total and Dissolved Metals (SW846-6010B, 7470A)	1 liter PE bottle Each	HN0 ₃ to pH <2	Hg 28 Days, Others, 6 months	IV
	GRO Method 8015B modified	2 - 40 ml VOA vials	HCl to pH <2/Cool to 4°C	14 Days (Analysis)	
	DRO SW846 8015B modified	2 - 1liter amber glass	Cool to 4°C	14 days extraction, 40 days to analysis	IV
	Specific Conductance (YSI 600XL [GW]; Horiba U-22 [SW])	Field Measurement	Not Applicable	Not Applicable	I
	pH (YSI 600XL [GW]; Horiba U22 [SW])	Field Measurement	Not Applicable	Not Applicable	I
	Temperature (YSI 600XL[GW], Horiba U-22 [SW])	Field Measurement	Not Applicable	Not Applicable	I
	Dissolved Oxygen (YSI 600XL [GW]; Horiba U-22[SW])	Field Measurement	Not Applicable	Not Applicable	I
	Turbidity (LaMotte turbidity meter [GW]; Horiba U-22 [SW])	Field Measurement	Not Applicable	Not Applicable	I
	Oxidation Reduction Potential (YSI 600XL [GW]; Horiba-22[SW])	Field Measurement	Not Applicable	Not Applicable	I

Note.

(1) USEPA and Naval Facilities Engineering Service Center Data Quality Objectives for laboratory data deliverables (see text)

(2) High concentration VOC samples will be preserved in 5 mls methanol analysis will be performed from the GRO vials.

* The reagent water VOC-preserved vials could be maintained at 4°C for 48 hours.

TABLE 3-4
FIELD QUALITY CONTROL SAMPLE SUMMARY
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

SAMPLE TYPE	MEDIA	ANALYSIS	FIELD SAMPLES ⁽¹⁾	FIELD DUPLICATES (1 PER 10 FIELD SAMPLES)	RINSATE BLANKS ⁽²⁾	SOURCE BLANKS (1 PER WATER SOURCE PER EVENT)	TRIP BLANKS (1 PER 10, 1 PER SHIPMENT)	TOTAL QUANTITY ⁽³⁾
Geologic/ Hydrogeologic Investigation	Soils	TCL VOCs	40	4	1	1	4	50
		TCL SVOCs	40	4	1	1	0	46
		Pesticides/PCBs	40	4	1	1	0	46
		TAL Metals	40	4	1	1	0	46
		GRO (8015B mod.)	40	4	1	1	4	50
		DRO	40	4	1	1	0	46
	Groundwater	TCL VOCs	5	1	1	0	1	8
		TCL SVOCs	5	1	1	0	0	7
		Pesticides/PCBs	5	1	1	0	0	7
		TAL total metals	5	1	1	0	0	7
		TAL dissolved metals	5	1	1	0	0	7
		GRO	5	1	1	0	1	8
		DRO	5	1	1	0	0	7

Notes:

- (1) Refer to Table 3-1 for number of field samples anticipated.
- (2) One rinsate blank per type of tool or sampling procedure used.
- (3) In order to accommodate laboratory quality control analyses (i.e., matrix spike, matrix spike duplicate, laboratory duplicate) the field crew will provide multiple aliquots of samples (as applicable) with a frequency of one per 20 samples of similar matrix.

Overburden aquifer wells will be installed according to the following protocol: clean silica sand of uniform grain size will be carefully placed under the well screen (6- inches minimum thickness) to provide a firm footing and allow unrestricted flow under the screened interval. The same uniform sand mixture will be placed in the annular space between the pre-packed well screen and boring wall, to a minimum of 1 foot above the top of the screen. A bentonite pellet seal with a minimum thickness of 2 feet will then be installed immediately above the silica sand backfill. The bentonite pellet seal will be brought up to 4 feet below ground surface. A 1-foot thick layer of clean silica sand (such as that used for the sand pack) will be added to serve as a drainage layer beneath the protective casing. This minimizes the possibility of water collecting and freezing in the annular space between the casing and the riser. The hole will be finished with a cement grout seal and a protective flush-mounted roadway box, where appropriate.

During the well installation process, the depths of all backfill materials will be continually monitored with a weighted tape. Wells will be completed at the ground surface using flush-mounted road boxes. Wells located within paved areas will be finished with concrete grout to match the existing grade of the surrounding paved surfaces.

Bentonite grout will be allowed to set for a minimum of 1 day prior to developing the well. Development will be conducted by bailing, or pumping and surging, to remove residual drill cuttings and fines from around the well screens.

The horizontal and vertical locations of the wells will be surveyed following the completion of well construction. The top of the PVC well riser will be marked for use as a permanent reference point. The survey operations are described in detail in Section 3.4 of this work plan. Well purge water will be containerized in accordance with Section 3.5 of this work plan.

3.3.4 Well Development

Wells will be developed by bailing and/or surging and pumping, as determined by the field geologist. Fine-grained material around the well screen will be drawn into the well and removed by agitating the well water with a foot valve and simultaneously pumping water from the well at a low discharge rate. A peristaltic pump outfitted with ASTM drinking water grade polyethylene tubing may also be used for removing the water from the well. To prevent cross contamination between the wells, the down hole equipment will be decontaminated between use in each well. The decontamination will use non-phosphate detergent and tap water, rinsed with tap water, rinsed with 2-propanol, and rinsed with deionized water. The polyethylene tubing will also be replaced between each well. Water produced

during well development will be containerized in 55-gallon drums (DOT Specification 17E), as described in Section 3.5 of this work plan, and placed in a locked storage container until disposal.

Based on field conditions, should the use of the surge block and pumping technique be deemed inappropriate by the TtNUS field team, an alternative method will be used to develop the well. A suitable pumping device (e.g., submersible bladder pump or a Whale[®] pump) will instead be placed in the well and used for its development.

The volume of groundwater extracted from each monitoring well during development will be monitored for the following water quality parameters: pH, temperature, oxidation reduction potential (ORP), specific conductance, dissolved oxygen, and turbidity at 15 minute intervals using a water quality meter. Development will continue until pH, temperature, and specific conductance have all stabilized and turbidity is equal to or less than 10 nephelometric turbidity units (NTUs). The well will be considered stable when consecutive readings differ less than 10 percent. If the NTU criteria is not achievable, the parties will determine if a turbidity standard of plus or minus 10 percent of successive well volumes is appropriate on a case-by-case basis. Development and/or purge water will be monitored with a FID or PID to aid in determining where the low flow sampling device will be placed.

If a well is not completely developed after 4 hours, the field geologist will notify the TtNUS project manager for authorization to continue or to stop development.

3.3.5 Groundwater Sample Collection

Investigations of groundwater quality have not been previously conducted at this site. One round of groundwater sampling and analysis will be conducted during this investigation. Due to concerns regarding high turbidity effects on the collection of representative, accurate, and reproducible groundwater quality samples, a low stress (low-flow) sample collection procedure will be used for this task. Samples will be collected from each of the newly installed micro wells and will include applicable field QA/QC samples (blanks and duplicates).

Groundwater samples will be analyzed for full TCL organics, TAL metals (total and dissolved metals), and DRO/GRO analyses. Table 3-1 presents a summary of field samples to be collected. Section 4.0 of this work plan describes analytical methodologies and QC requirements.

Work elements for this task include:

- Noting, measuring and, if possible, sampling non-aqueous phase liquids (both LNAPL and DNAPL).
- Measuring water levels in newly installed wells prior to purging, in addition to wells located on the OFFTA site.
- Purging wells using the low stress (low-flow) methodology.
- Periodically measuring pH, temperature, specific conductance, dissolved oxygen, ORP, turbidity, water level, and pumping rate while water is being extracted from the well.
- Collecting samples from the micro wells using the USEPA low stress (low-flow) methodology.
- Documenting, packing, and shipping samples for analysis.

Procedure

For each well to be sampled, the low stress (low flow) sample collection procedures to be followed are summarized below. The USEPA Region I SOP for low flow sample collection (SOP GW-0001, 7/30/96, Revision 2) is presented in Appendix B. This SOP will be followed, as practical, during the collection of groundwater samples. If the EPA method is unsuccessful in the collection of a groundwater sample, standard bailing techniques will be used.

The following steps provide a guideline for the low flow groundwater sample collection:

1. The presence of floating product in the wells will be determined with the use of an immiscible liquid interface probe (or equivalent). The presence of product will be noted, and if appropriate, the thickness measured and sampled (see Section 3.3.5.1 if applicable). The depth to water in the well will be measured and recorded to the nearest 0.01 feet, minimizing immersion of the meter within the standing water column to avoid disturbance of colloidal particles.
2. The required length of tubing will be calculated and measured for attachment to the pump intake placed at the appropriate saturated screened interval based on the presence of free product, elevated FID, PID, specific conductivity readings, odors, etc. Note that the tubing will be measured to allow a minimum distance between the well head and the discharge point (field testing equipment), to minimize temperature changes in the groundwater discharged from the well. Teflon or teflon-lined tubing will be used and disposed of after sampling is complete at each well.
3. The tubing will be slowly and smoothly lowered to the required depth to minimize the amount of mixing in the well. The pump's discharge tubing will be fastened to the well casing (or PVC stick-up) to minimize movement.

4. The field testing equipment will be assembled, and placed as close as possible to the well head/discharge tubing.
5. The depth to water with the pump in the well will be re-measured with the water level indicator or interface probe and compared with the initial reading; if the readings vary by more than 0.05 feet, field personnel will wait 5 minutes, re-measure the water, and begin pumping.
6. The pump will be started at a low speed setting until discharge occurs. The pump start time will be recorded, the flow rate measured (adjusted as necessary to within acceptable limits), and recorded using a graduated measuring device and stopwatch. (Note that during the initial period of pumping, an estimated 5 to 10 minutes, the depth to water in the well should be measured frequently (at an estimated frequency of approximately once per minute), to enable timely pump flow adjustments to attempt to minimize significant drawdown in the well).
7. During well purging, purge water discharged from the tubing will be collected in a flow-through cell. Water quality parameters for pH, temperature, specific conductance, ORP, and dissolved oxygen will be measured during purging using a YSI model 600 XL water quality meter (or equivalent) and recorded. Turbidity will be measured using a LaMotte 2020 (or equivalent) meter from a sample aliquot that is collected before it reaches the flow-through cell. The sample aliquot will be collected using an in-line T-fitting and ball valve or similar device.
8. Water quality parameters (pH, temperature, specific conductance, ORP, turbidity, and dissolved oxygen) and the depth to water in the well will be measured at 3 to 5-minute intervals as purging occurs. The data and the associated time will be recorded on the low-flow sampling data sheet. Attempts will be made to maintain the drawdown in the well during pumping to 0.3 feet or less, by adjusting the pump flow rate. Drawdown for each well will vary depending on the recharge capacity of the well. If stabilization of field parameters does not occur utilizing the low stress (low flow) procedure, the field crew will consult with the project manager, who will make the determination as whether to collect the sample or not. It is most likely that the sample will be collected and the data from that sample will have to be qualified with the information as to which parameters did not stabilize.
9. Purging will continue until all of the parameters have stabilized. "Stabilization" will be considered achieved when three consecutive readings are within the following limits:
 - Turbidity (10% for values greater than 1 NTU, as practical).
 - DO (10%).

- Specific conductance (3%).
- Temperature (3%).
- pH (± 0.1 unit).
- ORP/Eh (± 10 millivolts)

Groundwater samples will be collected following the stabilization of the measured field parameters. The discharge tubing will be disconnected from the flow-through cell and the in-line device used to collect aliquots for separate turbidity measurements. Samples will be collected directly through the discharge tubing into appropriate sample bottles. The sample aliquots for VOC and GRO analysis shall be collected directly into pre-preserved 40-mL amber vials with minimal disturbance. The bottles should be filled completely with no headspace remaining in the bottle. VOC/GRO samples shall not be opened after collection. An extra vial shall be collected initially to check the pH of the sample. If the desired pH is not obtained, five drops of hydrochloric acid (HCl) shall be placed into new 40-mL vials and the sample will be recollected. The process is repeated until pH < 2 is achieved. The samples shall be recollected with the appropriate amount of HCl. If effervescence is noted when the samples are collected, the samples shall be recollected without preservative and shipped to the laboratory as soon as possible. The holding time for not preserved VOC/GRO samples is 7 days. Samples will be preserved according to requirements described in Section 4.0. All non-disposable sampling equipment will be decontaminated prior to each use, as described in Section 3.5. All pertinent sampling data will be recorded on appropriate sample log sheets and in the site logbook. Any field deviations shall be recorded on a Field Modification Record.

If difficulties arise during low stress (low flow) sample collection procedures (i.e. minimum drawdown is not obtainable; it can't be documented that the well is yielding fresh water despite the drawdown; or water chemistry readings do not show a stabilization pattern), affected wells may be sampled using standard bailing techniques. This change will constitute a field modification request as described in Section 1.5 of this work plan.

Appropriate chain-of-custody procedures will be followed (see Section 4.3.2) and samples will be labeled, packaged, and shipped according to TtNUS SOP No. SA-6.1.

3.3.5.1 Non-Aqueous Phase Liquids (NAPL) Sampling

If light or dense non-aqueous phase liquids (LNAPL or DNAPL) are determined to be present in the micro wells, samples are to be collected prior to well purging, to avoid disruption of the NAPL layer. Two methods will be available for the collection of the free phase samples and will include:

1. Sampling by slowly lowering a "trap door" bailer or other vertical trap to the target depth measured with the interface probe, or
2. Sampling with a peristaltic pump by carefully lowering the teflon collection tube to the target depth measured with the interface probe.

The method selected will be based on the depth and apparent thickness of the non-aqueous phase liquid. Deeper (greater than 15 to 20 feet) and "thinner" layer samples (less than 0.1 foot) can make accurately placing the teflon collecting tubing for the peristaltic pump difficult. If necessary, product mixed with water can be collected and allowed to separate within a sample container. Once the NAPL layer has separated from the water portion of the sample, it may be extracted using a peristaltic pump under controlled conditions and containerized for analysis as required by the analytical laboratory.

3.4 TASK 3: LAND SURVEY

Following the investigative work, a survey will be performed by a surveyor registered in the State of Rhode Island to identify horizontal locations of sample points, and other significant features identified during the investigation. The survey will be performed by a subcontractor supervised by TtNUS working under the site specific Health and Safety Plan.

The base map presented in this work plan (Figure 3-1) will be used; however, locations of existing buildings and study area boundaries will be confirmed by survey.

The survey will be conducted to establish relative locations of sample points. Survey control will be maintained by tying into either the State of Rhode Island or United States Geological Survey (USGS) grid systems. Elevations will be referenced to a USGS benchmark and the Navy mean low water level. Horizontal and vertical measurements will be made relative to on-site control points.

All surveyed features will be horizontally located to within +/-0.1 foot. Tops of PVC well risers and will be located to plus or minus 0.01 foot vertically.

It is expected that each of the soil boring and micro well locations and elevations will require location surveying.

Surveyed points will be mapped with AutoCAD LT 2000i or a compatible system. The survey subcontractor will provide hard-copy prints and disk versions of the survey information for each survey operation. Survey points for each task will be set on different "layers" of the AutoCAD data such that printouts of sample collection points can be made specific to each task.

3.5 INVESTIGATION-DERIVED WASTE (IDW)

Waste materials that will be generated during the field investigation may include drill cuttings, well purge and development water, decontamination fluids, disposable sampling equipment, and used personal protective equipment (PPE).

TtNUS will be responsible for removing and properly disposing of all investigative waste materials following completion of the field investigation program. This waste disposal program will be conducted, as appropriate, following each of the tasks described in the previous sections of this work plan. In this manner, large quantities of wastes will not be stockpiled for disposal at the end of the investigation program.

Containers of IDW will be labeled as to their point of origin and date collected and placed in a locked storage container until disposal. Samples of these materials will be labeled with the information on the containers. Containers of IDW that are found to be hazardous will be characterized and disposed of within 90 days.

3.5.1 Solid Wastes

Personal protective equipment (gloves, tyvek coveralls, and disposable boots) will be decontaminated, double bagged, and disposed of in an off-site industrial dumpster.

3.5.2 Soil Wastes

Excess drill cuttings, discarded sample material, and other soil wastes will be containerized. Soils from different areas will not be mixed.

Laboratory analysis of samples collected during the investigation program will be used to further characterize the waste materials, as required by state and federal disposal requirements. Additional samples for other parameters will also be required. Typical disposal parameters are listed below.

- TCLP Metals
- TCLP Volatile Organic Compounds
- TCLP PCB/Pesticide Compounds
- Flash Point, Reactivity, Corrosivity
- Free Liquid

Analysis of representative samples of waste materials for disposal parameters will be the responsibility of an outside disposal subcontractor. All soil wastes will be shipped off site by this same subcontractor.

3.5.3 Liquid Wastes

Decontamination fluids and well purge and development water will be initially contained in 55-gallon drums. This material will be combined at the conclusion of the project and shipped off site for disposal in accordance with RIDEM, USEPA, and DOT Regulations.

3.6 DECONTAMINATION PROCEDURES

Equipment decontamination procedures are described in TITNUS SOP SA-7.1 and have been summarized below:

Monitoring Equipment

To the extent possible, all monitoring equipment will be wrapped and sealed in plastic with only the controls, readouts, and intake and exhaust ports open to the atmosphere. If decontamination of monitoring equipment is required, the following procedure will be utilized:

- Remove plastic covering.
- Remove gross contamination with potable water.
- Scrub with potable water/liquinox.
- Rinse lightly with potable water.
- Wipe dry immediately with disposable towels.

Drilling, Excavation, and Other Heavy Equipment

The DPT rigs and down hole equipment will be decontaminated following their arrival on site, prior to beginning work at each location, and at the completion of the drilling programs.

Rig decontamination will be performed at a temporary, centrally located decontamination pad constructed specifically for this purpose. The decontamination pad will be large enough to capture all wash water and channel it into a sump. The fluids in the sump will be containerized after each use.

Sampling Equipment

All non-disposable sampling equipment that comes in contact with the sample medium will be decontaminated to prevent cross contamination between sampling points. This includes equipment such as drill rods, soil sampling spatulas, and bowls, etc. The following decontamination sequence will be employed:

- Remove gross contamination by scrubbing with potable water.
- Scrub with potable water/liquinox.
- Rinse with potable water.
- Rinse with deionized water.
- Rinse with 2-propanol.
- Rinse with hexane
- Rinse with deionized water.
- Air dry (to extent possible).
- Wrap with aluminum foil, dull side toward equipment.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

This section provides technical guidelines and procedures for conducting the field work. This document references the TiNUS Standard Operating Procedures (SOPs) for specific protocols for procedures discussed in Section 3.0.

Pertinent SOPs are included in this work plan as Appendix B. These SOPs include, but are not limited to:

<u>SOP</u>	<u>DESCRIPTION</u>
GH-1.3	Soil Sampling
GH-1.5	Borehole and Sample Logging
GH-2.8	Groundwater Monitoring Well Installation
GH-2.5	Groundwater Contour Maps and Flow Determinations
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing
SA-2.5	Direct Push Technology
SA-6.1	Non-Radiological Sample Handling
SA-6.3	Field Documentation
ME-15	Photovac MicroFID Handheld Flame Ionization Detector

In addition, the following policies and guidance are provided for reference:

RIDEM (1996) Required Monitoring Well Construction Standards and Abandonment Procedures
 EPA-GW-0001 Low Flow Groundwater Sampling
 Total Volatile Organic Compounds Jar Headspace Screening

Data quality objectives for the SWOS site Focused SI are developed in Section 2.6 of this work plan. The objectives of the sampling program are to provide sufficient data to identify and characterize possible contaminants present in soils and groundwater at the site. This characterization and the data developed from the sampling program must be of adequate quality to support a baseline risk assessment, and to provide waste characterization data for making remedial decisions. To accomplish these objectives, samples will be collected for laboratory analyses as described in Section 3 of this work plan.

4.1 PARCC PARAMETERS

Achieving these objectives requires that the data collected from the field conform to an appropriate level of quality. The quality of a data set is measured by certain characteristics of the data, namely the precision and accuracy, representativeness, completeness, and comparability (PARCC) parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The PARCC goals for a particular project are determined by the intended use of the data, usually referred to as DQOs. DQOs are developed in Section 2.6 of this work plan; the PARCC parameters are discussed in the following subsections.

4.1.1 Precision and Accuracy

Field and laboratory precision and accuracy performance can affect the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples.

Analytical precision and accuracy will be evaluated upon receipt of the analytical (field screened and laboratory) data. Analytical precision will be measured as the relative percent difference from duplicate measurements and relative standard deviation from three or more replicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and matrix spike duplicate samples.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate TiNUS SOP, and by calibrating equipment properly and performing routine calibration checks, precision and accuracy errors associated with field activities can be minimized. The objective for measurement accuracy is to achieve and maintain the manufacturer's specifications for field equipment. Field duplicates and blanks (field, trip, and rinsate) will be used to estimate field sampling precision and accuracy for soil samples submitted for laboratory analysis.

Field duplicate and field quality control blank analyses results will be used during the data validation process to review the laboratory-analyzed results and determine the usability of the data with respect to its intended use. In general, results that are rejected by the data review process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable. Refer also to Section 4.10.2 of this Work Plan.

4.1.2 Representativeness

Representativeness describes the degree to which analytical data accurately and precisely define the population being measured. Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data (appropriate number of samples collected, physical state of the samples, site-specific factors, sampling equipment, containers, sample preservation and storage, holding times, sample identity and chain of custody will be defined to ensure that the samples analyzed represent the population being measured). The sampling program is designed to provide analytical data that is representative of the existing contaminant levels.

Every effort will be made to collect soil samples that represent the soil under investigation. For the headspace screening procedure the type and concentration of the contaminants in the samples screened on site depends on the type of contaminants present in the soil samples and their concentration. The volatile contaminants in the headspace represent the volatile contaminants in the soil in the container. The sample with the highest concentration of volatile contaminants in the soil will deliver the highest concentration of volatile contaminants to the headspace container.

Headspace screening data (FID/PID) will not be used to make determinations of true nature or extent of contamination. The screening data will be used to aid in determining micro well screen installation selection. The laboratory samples alone will be used to determine nature and extent of contamination as part of the Focused SI.

Representativeness of data is also affected by sampling techniques. Sampling techniques are described in Section 3.0 and in the TtNUS SOP included in Appendix B.

4.1.3 Completeness

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogeneity increase, completeness may decrease. Where analysis is precluded or where data quality objectives are compromised, effects on the overall investigation must be considered. Whether or not any particular sample is critical to the investigation will be evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

The sampling and analysis program for the site is sufficiently broad in scope to prevent a single data point or parameter from jeopardizing attainment of the monitoring objectives. Each medium is critical to

the assessment of contaminant migration. Consequently, there exists some critical data requirement below which the objectives of the monitoring program will be compromised.

Critical data points may not be evaluated until all the analytical results are evaluated. Additionally, several sampling points, in aggregate, may be considered to be critical either by location or by analysis. A subsequent sampling event may be necessary if it becomes apparent that the data for a specific medium are of insufficient quality, either with respect to the number of samples or an individual analysis.

For the purposes of this effort, a data point will be determined to contribute to the completeness of the data set if the information provided is meaningful, useful, and contributes to the project objectives.

4.1.4 Comparability

One of the objectives of the sampling effort is to provide analytical data that is characterized by a level of quality that is comparable between sampling points. By specifying the use of standard analytical procedures (as well as standardizing field sampling procedures by following TtNUS and other SOPs), the potential for variables to affect the final data quality will be effectively minimized. Analytical methods for this work are shown in Table 3-3, and SOPs appear in Appendix B.

4.2 QUALITY CONTROL SAMPLES

QC samples to be collected during the sampling effort are identified below, and include field duplicates, rinsate blanks, source blanks, trip blanks, and matrix spike/matrix spike duplicates. Each type of field quality control sample defined below will undergo the same preservation, holding times, etc., as the field samples. Table 3-4 presents a summary of these QC samples to be collected during this field investigation.

4.2.1 Field Duplicates

Field duplicates will be submitted at the rate of one for every 10 samples per matrix, or at a rate greater than one per 10 samples if less than 10 are collected. Field personnel will note on the sample summary form and in the logbook which samples are field duplicates. Duplicate samples will be shipped blind to the laboratories, and shipping paperwork will be completed accordingly.

Field personnel will note in the remarks block on the chain-of-custody form which of the samples is to be used for internal laboratory matrix spike/matrix spike duplicate analysis. Field duplicates and multiple sample aliquots are collected by mixing a double portion of the required volume of sample and dividing it

into two sample containers. Aliquots for VOC analysis are always removed prior to homogenization. Field duplicates provide precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis.

4.2.2 Rinsate Blanks

Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment after decontamination, immediately before sampling and placing it in the appropriate sample containers for analysis. These samples are used to assess the effectiveness of decontamination procedures. Rinsate blanks will be prepared at the rate of one per type of tool or sampling procedure used, and will be analyzed for the same parameters as the related samples. All rinsate samples will be sent to a laboratory for analysis.

4.2.3 Source Blanks

Source blanks will consist of the source water used in decontamination (includes analyte-free deionized water, potable water from each source, and other waters used in decontamination operations). Source blanks will be prepared at the rate of one per source of water per sampling event.

4.2.4 Trip Blanks

VOC and GRO trip blanks are prepared by the laboratories and are shipped to the field sampling team along with the containers to be used for sample collection. One VOC/GRO trip blank sample will accompany sample containers into the field, through the sampling process, and will be sent with each shipment of VOC and GRO samples to the laboratories. If there are multiple sampling crews out at one time, trip blanks will accompany each sampling team. If the samples are "pooled" in a single cooler for shipment, then the trip blanks accompanying each respective sampling team will be submitted for VOC analysis. For VOC soil samples the trip blank consist of two vials with 5 ml of VOC-free reagent water and one vial with 5 ml of methanol. The soil GRO trip blank will consist of one 5 ml methanol vial only.

4.2.5 Matrix Spike/Matrix Spike Duplicates

A matrix spike sample will be identified by field teams at a frequency of one in 20 field samples collected. Samples for matrix spike analyses are collected in triplicate volume, such that there are three containers for each analyte group. One aliquot is analyzed as a field sample in a manner consistent with the other field samples. The second aliquot is spiked and analyzed to determine spike recoveries. The

third is spiked also and analyzed as a duplicate to the second aliquot for the organic parameter or analyzed as a laboratory duplicate for the inorganic parameters.

4.3 PROJECT ACTION LIMITS AND METHOD DETECTION LIMITS

For the Focused SI at the SWOS site, a complete list of site contaminants has not yet been identified. Existing data indicate TPHs and lead are present on site, but extensive sample analysis has not been conducted on the SWOS site to indicate the full nature of the contamination. Therefore, the analyte groups and methods for analysis identified in Section 3 of this work plan have been selected for the Focused SI data collection effort. These methods provide the appropriate range of analytes identified by the USEPA on the TCL and TAL (metals) for CERCLA, which is the lead regulatory driver for the NAVSTA Newport Installation Restoration Program, under which this study is being conducted.

Project action limits are typically selected from available regulatory and risk based target concentrations, also referred to as benchmarks or screening criteria. The screening criteria for this project will include, but may not necessarily be limited to the regulatory criteria maximum contaminant levels (MCLs) for groundwater, RIDEM direct exposure criteria for soil and other human risk based criteria such as Region IX Preliminary Remediation Goals.

Method detection levels (MDLs) and quantitation limits (QLs) will be provided by the proposed subcontract laboratory. The project action limits are presented for soil (Tables 4-1A through 4-1D) and groundwater (Tables 4-2A through 4-2D). Action limits for soil were selected from the lowest criteria appropriate for human health risk as described within the table references. Action limits for groundwater were limited to human risk screening criteria for a water supply (EPA Region IX PRGs for tap water, and Rhode Island GB groundwater objectives), since the site is in an area classified as GB, and groundwater flow direction at the site is not yet determined. The MDLs and QLs from the assigned laboratory will be below the project detection limits.

The MDLs provided by the laboratory represent the minimum concentrations that can be quantified with the cited method for a given matrix. The QLs are about five to ten times higher than the MDLS. Many times, actual sample conditions, particularly in soil samples, will dictate the actual quantitation limit, which might be higher (or lower) than those stated. However, when the analytical laboratory identifies contaminants below their quantitation limit, they will report that detection as an approximate concentration. For this reason, results may be reported below the quantitation limits.

The project action limits are selected from risk-based and regulatory screening criteria as targets for the analytical laboratories and for the investigation. However, these are screening criteria, and some are

extremely low concentrations, and impossible to achieve without very specialized analytical work. It is expected that some laboratory MDLs will be above these risk criteria for some contaminants, just as it is predicted that some of the samples will not provide quantitation limits within the levels expected by the laboratory. Actual detection limits that fall above the targets will have to be considered in the data assessment processes.

4.4 SAMPLE DESIGNATION AND CUSTODY

Samples collected will be tracked by sample identification number and date and time of sample collection. The sample number will be the basis for maintaining chain of custody. These procedures are described below.

4.4.1 Sample Numbering

Samples will be labeled as soon as they are collected. Sample numbers will reflect the source, medium, and location. An alpha numeric numbering system will be used to describe this information. This system is detailed below:

AAAA - A - AANN -NNNN - NN
(Site Identifier) - (Medium) - (Sample Location) - (Depth)- (Round)

The site identifier for the SWOS site is SWOS. "Medium" indicates solid (S) or aqueous (A). Sample locations will be noted as UW for groundwater samples from micro wells and SB for soil boring samples. The addition of the sampling round number is only applicable to groundwater samples.

For example, a soil boring sample collected from 2-4 feet below ground surface from SB03 will be identified as SWOS-S-SB03-0204. The first groundwater sample (Round 1) collected from the micro well will be identified as SWOS-A-UW04-01.

Blind duplicate samples will be designated such that the location designation will be replaced with a chronological number:

Duplicates: SWOS-S-SB-DUP##

TABLE 4-1A
SOIL- VOLATILE ORGANIC TARGET ANALYTES, METHOD 5035/ 8260B
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs* (µg/kg)	QLs (µg/kg)
Dichlorodifluoromethane	75-71-8	9,400	HH	10		10
Chloromethane	74-87-3	1,200	HH	10		10
Bromomethane	74-83-9	390	HH	10		10
Vinyl Chloride	75-01-4	20	RIDEM	10		10
Chloroethane	75-00-3	3,000	HH	10		10
Methylene Chloride	75-09-2	9,100	HH	10		10
Acetone	67-64-1	160,000	HH	10		10
Methyl Acetate	79-20-9	2,200,000	HH	10		10
Carbon Disulfide	75-15-0	36,000	HH	10		10
Trichlorofluoromethane	75-69-4	39,000	HH	10		10
1,1-Dichloroethene	75-35-4	200	RIDEM	10		10
1,1,2-Trichloro-1,2,2-trifluoro-ethane	76-13-1	5,600,000	HH	10		10
1,1- Dichloroethane	75-34-3	51,000	HH	10		10
Methyl tert-Butyl Ether	1634-04-4	62,000	HH	10		10
cis-1,2- Dichloroethene	156-59-2	4,300	HH	10		10
trans-1,2- Dichloroethene	156-60-5	6,900	HH	10		10
Chloroform	67-66-3	360	HH	10		10
1,2- Dichloroethane	107-06-2	280	HH	10		10
2-Butanone	78-93-3	730,000	HH	10		10
1,1,1-Trichloroethane	71-55-6	540,000	RIDEM	10		10
Bromochloromethane	74-97-5	2,400	HH	10		10
Cyclohexane	110-82-7	140,000	HH	10		10
Carbon Tetrachloride	56-23-5	250	HH	10		10
Bromodichloromethane	75-27-4	820		10		10
Methylcyclohexane	108-87-2	260,000	HH	10		10
1,2-Dichloropropane	78-87-5	340	HH	10		10
Cis-1,3- Dichloropropene	10061-01-5	NA		10		10
Trichloroethene	79-01-6	53	HH	10		10
Dibromochloromethane	124-48-1	1,100	HH	10		10
1,1,2- Trichloroethane	79-00-5	730	HH	10		10
Benzene	71-43-2	600	HH	10		10
Trans-1,3-Dichloropropene	10061-02-6	NA		10		10
Isopropylbenzene	98-82-8	57,000	HH	10		10
Bromoform	75-25-2	62,000	HH	10		10
4-Methyl-2-Pentanone	108-10-1	79,000	HH	10		10
2-Hexanone	591-78-6	NA		10		10
Tetrachlorethene	127-18-4	1,500	HH	10		10
1,1,2,2- Tetrachlorethane	79-34-5	410	HH	10		10
Ethylene Dibromide	106-93-4	6.9	HH	10		10
Toluene	108-88-3	190,000	RIDEM	10		10
1,2-Dibromoethane	106-93-4	6.9	HH	10		10
Chlorobenzene	108-90-7	15,000	HH	10		10

TABLE 4-1A (c nt.)
 SOIL- VOLATILE ORGANIC TARGET ANALYTES, METHOD 5035/8260B
 DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND
 PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs* (µg/kg)	QLs (µg/kg)
Ethylbenzene	100-41-4	8,900	HH	10		10
Styrene	100-42-5	13,000	RIDEM	10		10
Total Xylenes	1330-20-7	27,000	HH	10		10
1,3-Dichlorobenzene	541-73-1	1,600	HH	10		10
1,4- Dichlorobenzene	106-46-7	3,400	HH	10		10
1,2- Dichlorobenzene	95-50-1	370,000	HH	10		10
1,2-Dibromo-3-chloropropane	96-12-8	450	HH	10		10
1,2,4-Trichlorobenzene	120-82-1	65,000	HH	10		10

Notes:

* Laboratory to be determined.

Bold Achievable laboratory Quantitation limit is above the project action limit, however the MDL should be below the action limit.

NA Not available

Sources in preferential order:

HH - EPA Region IX PRGs for residential use soils

RIDEM – Rhode Island Direct Exposure Criteria for Residential Soils

TABLE 4-1B
SOIL- SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270C
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs* (µg/kg)	QLs (µg/kg)
Benzaldehyde	100-52-7	610,000	HH	330		330
Phenol	108-95-2	6,000,000	RIDEM	330		330
Bis-(2-Chloroethyl) ether	111-44-4	210	HH	330		330
2-Chlorophenol	95-57-8	6300	HH	330		330
2-Methylphenol	95-48-7	30,000	HH	330		330
2,2-oxybis(1-Chloropropane)	108-60-1	2,900	HH	330		330
Acetophenone	98-86-2	NA		330		330
4-Methylphenol	106-44-5	31,000	HH	330		330
N-Nitroso-di-n propylamine	621-64-7	69	HH	330		330
Hexachloroethane	67-72-1	35,000	HH	330		330
Nitrobenzene	98-95-3	2,000	HH	330		330
Isophorone	78-59-1	510,000	HH	330		330
2-Nitrophenol	88-75-5	NA		330		330
2,4-Dimethylphenol	105-67-9	120,000	HH	330		330
Bis(2-Chloroethoxy) methane	111-91-1	NA		330		330
2,4-Dichlorophenol	120-83-2	18,000	HH	330		330
Naphthalene	91-20-3	5,600	HH	330		330
4-Chloroaniline	106-47-8	24,000	HH	330		330
Hexachlorobutadiene	87-68-3	6,200	HH	330		330
Caprolactam	105-60-2	3,100,000	HH	330		330
4-Chloro-3-methylphenol	59-50-7	NA		330		330
2-Methylnaphthalene	91-57-6	NA		330		330
Hexachlorocyclopentadiene	77-47-4	37,000	HH	330		330
2,4,6-Trichlorophenol	88-06-2	610	HH	330		330
2,4,5-Trichlorophenol	95-95-4	330,000	RIDEM	830		830
1,1'-Biphenyl	92-52-4	NA	HH	330		330
2-Chloronaphthalene	91-58-7	490,000	HH	330		330
2-Nitroaniline	88-74-4	170	HH	830		830
Dimethylphthalate	131-11-3	1,900,000	RIDEM	330		330
2,6-Dinitrotoluene	606-20-2	6,100	HH	330		330
Acenaphthylene	208-96-8	23,000	RIDEM	330		330
3-Nitroaniline	99-09-2	NA		830		830
Acenaphthene	83-32-9	43,000	RIDEM	330		330
2,4-Dinitrophenol	51-28-5	12,000	HH	830		830
4-Nitrophenol	100-02-7	NA		830		830
Dibenzofuran	132-64-9	29,000	HH	330		330
2,4-Dinitrotoluene	121-14-2	900	RIDEM	330		330
Diethylphthalate	84-66-2	340,000	RIDEM	330		330
Fluorene	86-73-7	28,000	RIDEM	330		330
4-Chlorophenyl-phenyl ether	7005-72-3	NA		330		330
4-Nitroaniline	100-01-6	NA		830		830

TABLE 4-1B (cont.)
 SOIL- SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270C
 DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
 SURFACE WARFARE OFFICERS SCHOOL
 NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND
 PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs* (µg/kg)	QLs (µg/kg)
4,6-Dinitro-2-methylphenol	534-52-1	NA		830		830
N-Nitroso diphenylamine	86-30-6	9,900	HH	330		330
4-Bromophenyl-phenylether	101-55-3	NA		330		330
Hexachlorobenzene	118-74-1	300	HH	330		330
Atrazine	1912-24-9	2,200	HH	330		330
Pentachlorophenol	87-86-5	3,000	HH	830		830
Phenanthrene	85-01-8	40,000	RIDEM	330		330
Anthracene	120-12-7	35,000	RIDEM	330		330
Carbazole	86-74-8	24,000	HH	330		330
Di-n-butylphthalate	84-74-2	610,000	HH	330		330
Fluoranthene	206-44-0	20,000	RIDEM	330		330
Pyrene	129-00-0	13,000	RIDEM	330		330
Butylbenzylphthalate	85-68-7	1,200,000	HH	330		330
3,3'-Dichlorobenzidine	91-94-1	1,100	HH	330		330
Benzo (a) anthracene	56-55-3	620	HH	330		330
Chrysene	218-01-9	400	RIDEM	330		330
bis(2-Ethylhexyl) phthalate	117-81-7	35,000	HH	330		330
Di-n-octylphthalate	117-84-0	240,000	HH	330		330
Benzo (b) fluoroanthene	205-99-2	620	HH	330		330
Benzo (k) fluoroanthene	207-08-9	900	RIDEM	330		330
Benzo (a) pyrene	50-32-8	62	HH	330		330
Indeno (1,2,3-cd)-pyrene	193-39-5	620	HH	330		330
Dibenzo (a,h)-anthracene	53-70-3	62	HH	330		330
Benzo (g,h,i) perylene	191-24-2	800	RIDEM	330		330

Notes:

* Laboratory to be determined.

Bold Achievable laboratory quantitation limit is above the project action limit.

NA Not available

Sources in preferential order:

HH - EPA Region IX PRGs for residential use soils

RIDEM – Rhode Island Direct Exposure Criteria for Residential Soils

TABLE 4-1C
SOIL – PESTICIDES/PCB TARGET ANALYTES, METHODS 8081/8082
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/kg)	Source	Project Quantitation Limit (µg/kg)	Achievable Laboratory Limits	
					MDLs* (µg/kg)	QLs (µg/kg)
alpha-BHC	319-84-6	90	HH	1.7		1.7
beta-BHC	319-85-7	320	HH	1.7		1.7
delta-BHC	319-86-8	NA		1.7		1.7
gamma-BHC	58-89-9	440	HH	1.7		1.7
Heptachlor	76-44-8	110	HH	1.7		1.7
Aldrin	309-00-2	29	HH	1.7		1.7
Heptachlor epoxide	1024-57-3	53	HH	1.7		1.7
Endosulfan I	959-98-8	NA		1.7		1.7
Endosulfan II	33213-65-9	NA		3.3		3.3
Endosulfan sulfate	1031-07-8	NA		3.3		3.3
Dieldrin	60-57-1	30	HH	3.3		3.3
Endrin	72-20-8	1,800	HH	3.3		3.3
Endrin ketone	53494-70-5	NA		3.3		3.3
Endrin aldehyde	7421-93-4	NA		3.3		3.3
4,4'-DDE	72-55-9	1,700	HH	3.3		3.3
4,4'-DDD	72-54-8	2,400	HH	3.3		3.3
4,4'-DDT	50-29-3	1,700	HH	3.3		3.3
Methoxychlor	72-43-5	31,000	HH	17		17
alpha-Chlordane	5103-71-9	NA		1.7		1.7
gamma-Chlordane	5103-74-2	NA		1.7		1.7
Toxaphene	8001-35-2	440	HH	170		170
Aroclor-1016	12674-11-2	390	HH	33		33
Aroclor-1221	11104-28-2	220	HH	67		67
Aroclor-1232	11141-16-5			33		33
Aroclor-1242	53469-21-9			33		33
Aroclor-1248	12672-29-6			33		33
Aroclor-1254	11097-69-1			33		33
Aroclor-1260	11096-82-5			33		33

Notes:

* Laboratory to be determined.

Bold Achievable laboratory quantitation limit is above the project action limit, however the MDL should be below the action limit.

NA Not available

Sources in preferential order:

HH - EPA Region IX PRGs for residential use soils

RIDEM – Rhode Island Direct Exposure Criteria for Residential Soils

TABLE 4-1D
SOIL- METALS TARGET ANALYTES METHOD 6010B AND 7471A
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (mg/kg)	Source	Project Quantitation Limit (mg/kg)	Achievable Laboratory Limits	
					MDLs* (mg/kg)	QLs (mg/kg)
Aluminum	7429-90-5	7,600	HH	30		30
Antimony	7440-36-0	3.1	HH	0.8		0.8
Arsenic†	7440-38-2	0.39	HH	0.5		0.5
Barium	7440-39-3	540	HH	0.5		0.5
Beryllium	7440-41-7	0.4	RIDEM	1.0		1.0
Cadmium	7440-43-9	3.7	HH	5.0		5.0
Calcium	7440-70-2	NA		1.5		1.5
Chromium	7440-47-3	30	HH	3.0		3.0
Cobalt	7440-48-4	900	HH	2.5		2.5
Copper	7440-50-8	310	HH	1.0		1.0
Iron	7439-89-6	2,300	HH	10		10
Lead	7439-92-1	150	RIDEM	0.5		0.5
Magnesium	7439-95-4	NA		5.0		5.0
Manganese	7439-96-5	180	HH	0.5		0.5
Mercury	7439-97-6	2.3	HH	0.05		0.05
Nickel	7440-02-0	160	HH	4.0		4.0
Potassium	7440-09-7	NA		100		100
Selenium	7782-49-2	39	HH	1.0		1.0
Silver	7440-22-4	39	HH	1.5		1.5
Sodium	7440-23-5	NA		100		100
Thallium †	7440-28-0	0.52	HH	1.5		1.5
Vanadium	7440-62-2	55	HH	2.5		2.5
Zinc	7440-66-6	2,300	HH	2.5		2.5

Notes:

* Laboratory to be determined.

Bold Achievable laboratory quantitation limit is above the project action limit, however the MDL should be below the action limit.

NA Not available

† Arsenic and thallium to be analyzed by Method 6020, others by Method 6010B.

Sources in preferential order:

HH - EPA Region IX PRGs for residential use soils

RIDEM – Rhode Island Direct Exposure Criteria for Residential Soils

TABLE 4-2A
GROUNDWATER – VOLATILE ORGANIC TARGET ANALYTES, METHOD 8260B
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs (µg/L)	QLs (µg/L)
Dichlorodifluoromethane	75-71-8	390	1		1
Chloromethane	74-87-3	15	1		1
Bromomethane	74-83-9	0.87	1		1
Vinyl Chloride	75-01-4	0.02	1		1
Chloroethane	75-00-3	46	1		1
Methylene Chloride	75-09-2	4.3	1		1
Acetone	67-64-1	61	1		1
Methyl Acetate	79-20-9	610	1		1
Carbon Disulfide	75-15-0	100	1		1
Trichlorofluoromethane	75-69-4	130	1		1
1,1-Dichloroethene	75-35-4	34	1		1
1,1,2-Trichloro-1,2,2-trifluoro-ethane	76-13-1	5900	1		1
1,1- Dichloroethane	75-34-3	81	1		1
Methyl tert-Butyl Ether	1634-04-4	13	1		1
cis-1,2- Dichloroethene	156-59-2	61	1		1
trans-1,2- Dichloroethene	156-60-5	12	1		1
Chloroform	67-66-3	6.2	1		1
1,2- Dichloroethane	107-06-2	0.12	1		1
2-Butanone	78-93-3	190	1		1
1,1,1-Trichloroethane	71-55-6	320	1		1
Cyclohexane	110-82-7	3500	1		1
Carbon Tetrachloride	56-23-5	0.17	1		1
Bromodichloromethane	75-27-4	0.18	1		1
Methylcyclohexane	108-87-2	520	1		1
1,2-Dichloropropane	78-87-5	0.16	1		1
cis-1,3- Dichloropropene	10061-01-5	NA	1		1
Trichloroethene	79-01-6	0.028	1		1
Dibromochloromethane	124-48-1	0.13	1		1
1,1,2- Trichloroethane	79-00-5	0.2	1		1
Benzene	71-43-2	0.34	1		1
Trans-1,3-Dichloropropene	10061-02-6	NA	1		1
Isopropylbenzene	98-82-8	66	1		1
Bromoform	75-25-2	8.5	1		1
4-Methyl-2-Pentanone	108-10-1	16	1		1
2-Hexanone	591-78-6	NA	1		1
Tetrachlorethene	127-18-4	0.66	1		1
1,1,2,2- Tetrachlorethene	79-34-5	0.055	1		1
Toluene	108-88-3	72	1		1
1,2-Dibromoethane	106-93-4	0.00076	1		1

TABLE 4-2A (cont.)
GROUNDWATER – VOLATILE ORGANIC TARGET ANALYTES, METHOD 8260B
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND
PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs* (µg/L)	QLs (µg/L)
Chlorobenzene	108-90-7	11	1		1
Ethylbenzene	100-41-4	2.9	1	0.267	1
Styrene	100-42-5	160	1	0.409	1
Total Xylenes	1330-20-7	21	1	0.546	1
1,3-Dichlorobenzene	541-73-1	0.55	1	0.302	1
1,4- Dichlorobenzene	106-46-7	0.5	1	0.161	1
1,2- Dichlorobenzene	95-50-1	37	1	0.181	1
1,2-Dibromo-3-chloropropane	96-12-8	0.048	1	0.569	1
1,2,4-Trichlorobenzene	120-82-1	19	1	0.743	1

Notes:

* Laboratory to be determined.

Bold Achievable laboratory detection limit is above the project action limit.

NA Not applicable.

(1) Region IX Preliminary Remediation Goals for Tap Water, unless otherwise specified

(2) Rhode Island GB Groundwater Objectives

TABLE 4-2B
GROUNDWATER – SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270C
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs (µg/L)*	QLs (µg/L)
Benzaldehyde	100-52-7	360	10		10
Phenol	108-95-2	2200	10		10
Bis-(2-Chloroethyl) ether	111-44-4	0.0098	10		10
2-Chlorophenol	95-57-8	3	10		10
2-Methylphenol	95-48-7	180	10		10
2,2-oxybis(1-Chloropropane)	108-60-1	0.27	10		10
Acetophenone	98-86-2	0.042	10		10
4-Methylphenol	106-44-5	18	10		10
N-Nitroso-di-n propylamine	621-64-7	0.0096	10		10
Hexachloroethane	67-72-1	4.8	10		10
Nitrobenzene	98-95-3	0.34	10		10
Isophorone	78-59-1	71	10		10
2-Nitrophenol	88-75-5	NA	10		10
2,4-Dimethylphenol	105-67-9	73	10		10
Bis(2-Chloroethoxy) methane	111-91-1	NA	10		10
2,4-Dichlorophenol	120-83-2	11	10		10
Naphthalene	91-20-3	0.62	10		10
4-Chloroaniline	106-47-8	15	10		10
Hexachlorobutadiene	87-68-3	0.86	10		10
Caprolactam	105-60-2	1800	10		10
4-Chloro-3-methylphenol	59-50-7	NA	10		10
2-Methylnaphthalene	91-57-6	NA	10		10
Hexachlorocyclopentadiene	77-47-4	22	10		10
2,4,6-Trichlorophenol	88-06-2	0.38	10		10
2,4,5-Trichlorophenol	95-95-4	360	25		25
1,1'-Biphenyl	92-52-4	30	10		10
2-Chloronaphthalene	91-58-7	49	10		10
2-Nitroaniline	88-74-4	0.1	25		25
Dimethylphthalate	131-11-3	36,000	10		10
2,6-Dinitrotoluene	606-20-2	3.6	10		10
Acenaphthylene	208-96-8	NA	10		10
3-Nitroaniline	99-09-2	NA	25		25
Acenaphthene	83-32-9	37	10		10
2,4-Dinitrophenol	51-28-5	7.3	25		25
4-Nitrophenol	100-02-7	290*	25		25
Dibenzofuran	132-64-9	2.4	10		10
2,4-Dinitrotoluene	121-14-2	7.3	10		10
Diethylphthalate	84-66-2	2,900	10		10
Fluorene	86-73-7	24	10		10
4-Chlorophenyl-phenyl ether	7005-72-3	NA	10		10
4-Nitroaniline	100-01-6	NA	25		25

TABLE 4-2B (cont.)
GROUNDWATER – SEMIVOLATILE ORGANIC TARGET ANALYTES, METHOD 8270C
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND
PAGE 2 OF 2

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs (µg/L)*	QLs (µg/L)
N-Nitroso diphenylamine	86-30-6	14	10		10
4-Bromophenyl-phenylether	101-55-3	NA	10		10
Hexachlorobenzene	118-74-1	0.042	10		10
Atrazine	1912-24-9	0.3	10		10
Pentachlorophenol	87-86-5	0.56	25		25
Phenanthrene	85-01-8	NA	10		10
Anthracene	120-12-7	180	10		10
Carbazole	86-74-8	3.4	10		10
Di-n-butylphthalate	84-74-2	360	10		10
Fluoranthene	206-44-0	150	10		10
Pyrene	129-00-0	18	10		10
Butylbenzylphthalate	85-68-7	730	10		10
3,3'-Dichlorobenzidine	91-94-1	150	10		10
Benzo (a) anthracene	56-55-3	0.092	10		10
Chrysene	218-01-9	9.2	10		10
bis(2-Ethylhexyl) phthalate	117-81-7	4.8	10		10
Di-n-octylphthalate	117-84-0	730	10		10
Benzo (b) fluoroanthene	205-99-2	0.092	10		10
Benzo (k) fluoroanthene	207-08-9	0.92	10		10
Benzo (a) pyrene	50-32-8	0.0092	10		10
Indeno (1,2,3-cd)-pyrene	193-39-5	0.092	10		10
Dibenzo (a,h)-anthracene	53-70-3	0.0092	10		10
Benzo (g,h,i) perylene	191-24-2	NA	10		10

Notes:

* Laboratory to be determined.

Bold Achievable laboratory quantitation limit is above the project action limit.

NA Not available

Sources in preferential order:

HH - EPA Region IX PRGs for residential use soils

RIDEM – Rhode Island Direct Exposure Criteria for Residential Soils

TABLE 4-2C
GROUNDWATER – PESTICIDE/PCB TARGET ANALYTES, METHOD 8081/8082
DRAFT FINAL WORK PLAN – FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs* (µg/L)	QLs (µg/L)
alpha-BHC	319-84-6	0.011	0.050		0.050
beta-BHC	319-85-7	0.037	0.050		0.050
delta-BHC	319-86-8	NA	0.050		0.050
gamma-BHC	58-89-9	0.052	0.050		0.050
Heptachlor	76-44-8	3.6 ⁽³⁾	0.050		0.050
Aldrin	309-00-2	0.004	0.050		0.050
Heptachlor epoxide	1024-57-3	3.6 ⁽³⁾	0.050		0.050
Endosulfan I	959-98-8	NA	0.050		0.050
Dieldrin	60-57-1	0.0042	0.10		0.10
4,4'-DDE	72-55-9	0.2	0.10		0.10
Endrin	72-20-8	1.1	0.10		0.10
Endosulfan II	33213-65-9	220	0.10		0.10
4,4'-DDD	72-54-8	0.28	0.10		0.10
Endosulfan sulfate	1031-07-8	NA	0.10		0.10
4,4'-DDT	50-29-3	0.2	0.10		0.10
Methoxychlor	72-43-5	18	0.50		0.50
Endrin ketone	53494-70-5	NA	0.10		0.10
Endrin aldehyde	7421-93-4	NA	0.10		0.10
alpha-Chlordane	5103-71-9	0.2	0.050		0.050
gamma-Chlordane	5103-74-2	0.2	0.050		0.050
Toxaphene	8001-35-2	0.061	5.0		5.0
Aroclor-1016	12674-11-2	1.0	1.0		1.0
Aroclor-1221	11104-28-2	0.034	2.0		2.0
Aroclor-1232	11141-16-5	0.034	1.0		1.0
Aroclor-1242	53469-21-9	0.034	1.0		1.0
Aroclor-1248	12672-29-6	0.034	1.0		1.0
Aroclor-1254	11097-69-1	0.034	1.0		1.0
Aroclor-1260	11096-82-5	0.034	1.0		1.0

Notes:

* Laboratory to be determined.

Bold Achievable laboratory quantitation limit is above the project action limit.

NA Not available

Sources in preferential order:

HH - EPA Region IX PRGs for residential use soils

RIDEM – Rhode Island Direct Exposure Criteria for Residential Soils

TABLE 4-2D
GROUNDWATER METALS TARGET ANALYTES, METHOD 6010B/7470A
DRAFT FINAL WORK PLAN - FOCUSED SITE INSPECTION
SURFACE WARFARE OFFICERS SCHOOL
NAVAL STATION, NEWPORT, RHODE ISLAND

Analytes	CAS Number	Project Action Limit (µg/L) ⁽¹⁾	Project Quantitation Limit (µg/L)	Achievable Laboratory Limits	
				MDLs (µg/L) ⁽³⁾	QLs (µg/L)
Aluminum	7429-90-5	3,600	200		200
Antimony	7440-36-0	1.5	8		8
Arsenic	7440-38-2	0.045	5		5
Barium	7440-39-3	260	200		200
Beryllium	7440-41-7	7.3	5		5
Cadmium	7440-43-9	1.8	2		2
Calcium	7440-70-2	NA	5000		5000
Chromium	7440-47-3	100	10		10
Cobalt	7440-48-4	73	50		50
Copper	7440-50-8	150	25		25
Iron	7439-89-6	1,100	100		100
Lead	7439-92-1	15	5		5
Magnesium	7439-95-4	NA	5000		5000
Manganese	7439-96-5	88	15		15
Mercury	7439-97-6	1.1	0.2		0.2
Nickel	7440-02-0	73	40		40
Potassium	7440-09-7	NA	5000		5000
Selenium	7782-49-2	18	5		5
Silver	7440-22-4	18	10		10
Sodium	7440-23-5	NA	5000		5000
Thallium	7440-28-0	0.24	5		5
Vanadium	7440-62-2	26	10		10
Zinc	7440-66-6	1,100	20		20

Notes:

* Laboratory to be determined.

Bold Achievable laboratory quantitation limit is above the project action limit.**NA** Not availableSources in preferential order:

HH - EPA Region IX PRGs for residential use soils

RIDEM – Rhode Island Direct Exposure Criteria for Residential Soils

Source blanks will be designated such that they can clearly be identified as source blanks. The designation must be able to be referenced to the source (e.g. DIUF or HPLC water) using the field paperwork.

Source Blanks: SWOS-A-DIUF-SB##

Rinsate blanks will be identified using the code for the sample for which the tool was last used, the identifier (RB), and its chronological number.

Rinsate Blanks: SWOS-A-SB01-0204-RB##

Trip blanks associated with groundwater will be designated so that they can clearly be identified as aqueous trip blanks using an identifier (TB) and its chronological number. Trip blank associated with soil samples will be identified as soil trip blanks.

Trip Blanks:	SWOS-A-TB##	groundwater
	SWOS-S-TB##	soil

Matrix spike samples are simply marked as Lab QC in the "Remarks" section of the chain of custody Record form.

4.4.2 Sample Chain of Custody

Custody of samples must be maintained and documented at all times. To ensure the integrity of a sample from collection through analysis, an accurate written record is necessary to trace the possession and handling of the sample. This documentation is referred to as the "chain of custody". Chain of custody begins when samples are collected in the field, and is maintained by storing the samples in secure areas until custody can be passed on. All samples will be accompanied by a chain-of-custody form that will describe the analytical parameters, and the persons who are responsible for its integrity.

Samples will be placed on ice and attended by TtNUS personnel or placed in locked vehicles or designated storage areas until analysis or shipment to an off-site laboratory. Chain-of-custody procedures are described in further detail in the SOPs presented in Appendix B of this work plan.

4.5 CALIBRATION PROCEDURES

Field equipment requiring calibration will be calibrated and operated in accordance with the manufacturer's instructions and manuals. A log will be kept on site, documenting the periodic calibration results for each field instrument. Field equipment will be calibrated in the morning, and the calibration will be checked in the evening.

Calibration procedures for laboratory equipment used in the analysis of environmental samples will be performed in accordance with NFESC requirements and contract requirements under the Master Services Agreement (MSA) and the laboratory specifications i.e., CLP deliverable requirements for level IV data reports.

4.6 LABORATORY ANALYSIS

Samples collected will be analyzed for various parameters described in previous sections and listed in Table 3-1 and 3-3.

The environmental samples collected for laboratory analysis during the field investigation will be analyzed by a laboratory previously approved by the Navy. Standard EPA analytical procedures will be employed, as depicted in Table 3-3. Validation of data will be performed according to EPA Region I Tier II Validation as is appropriate for data used for evaluation of risk under CERCLA described in Section 2.6 of this work plan.

4.7 DATA REDUCTION, REVIEW, AND REPORTING

Laboratory analytical data will be reviewed by qualified TtNUS technical staff. Laboratory data will undergo a data validation equivalent to EPA Region I Tier II validation. Data validation memoranda will be prepared and submitted to the project manager as a part of that activity. Data validation procedures are described in Section 4.0 of this work plan.

Field data will be periodically reviewed by technical lead personnel and the TtNUS project manager to ensure that the data that is collected is well documented, clearly described, and meets a standard appropriate for the investigation and its ultimate use.

4.8 INTERNAL QUALITY CONTROL

Section 4.2 discussed the types and frequency of quality control samples that will be prepared during the field investigation activities for those samples to undergo laboratory analysis. The quantities of the various types of the QC samples are shown in Table 3-4. Laboratory analysis will follow the QC criteria described in the analytical procedures.

4.9 PERFORMANCE AND SYSTEM AUDITS

System audits will be performed as appropriate to ensure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner.

- The FOL will supervise and on a daily basis check to ensure that the equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.
- The data reviewer(s) will review the data and will check that the data was obtained through the approved methodology, and that the appropriate level of QC effort and reporting were conducted. The data validation effort will be supervised by the TtNUS CLEAN Quality Assurance Manager or designee.
- The PM will oversee the FOL and data reviewer, and check that management of the acquired data proceeds in an organized and expeditious manner.

4.10 DATA ASSESSMENT PROCEDURES

The following paragraphs describe the procedures used to evaluate data prior to inclusion and description in the deliverable reports described elsewhere in this work plan.

4.10.1 Representativeness, Accuracy, and Precision

All laboratory data generated in the investigation will be assessed for representativeness, accuracy, and precision, as described in Section 4.1. The completeness of the data will also be assessed by comparing the acquired data to the project objectives to see that these objectives are being addressed and met. The specific information used to determine data precision, accuracy, and completeness will be provided in the laboratory data packages.

The PARCC parameter assessment will be conducted by qualified TtNUS personnel. The representativeness of the data will be assessed by determining if the data are consistent with known or anticipated chemical conditions and accepted principles.

Field measurements will be checked for completeness of procedures and documentation of procedures and results.

Precision and accuracy will be determined using replicate samples and blank and spiked samples, respectively. PARCC parameters are addressed in more detail in Section 4.1.

4.10.2 Data Validation

Samples will be analyzed for parameters described on Table 3-3 of this work plan. The VOC and SVOC sample data will be validated using a Tier II validation protocol in accordance with Functional Guidelines for Evaluating Environmental Analyses (U.S. EPA, December 1996). The pesticide/PCB sample data will be validated using a Tier II validation protocol in accordance with Region I, EPA Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses (U.S. EPA, February 2004). The TAL metals analytical data will be validated using a Tier II validation protocol in accordance with Region I, EPA-NE Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses (modified February 1989). Use of these validation protocols is allowed under the NFESC (formerly NEESA) guidelines and is described in the Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Document (revised February 1996), and the NEESA 20.2047B; June 1988 guidelines.

This level of validation is appropriate for data used for evaluation of risk under CERCLA described in Section 2.6 of this work plan.

4.11 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve non-conformance with the SOPs and/or analytical procedures established for the project, or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the FOL and the PM. The PM, with the assistance of the Quality Assurance Manager and the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the corrective action has been effective.

Corrective actions may include re-sampling and/or re-analysis of samples or modifying project procedures. If warranted by the severity of the problem (for example, if a change in the approved work

plan is required), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Additional work that is dependent on a nonconforming activity will not be performed until the source of the problem has been addressed.

4.12 DOCUMENTATION

A bound/weatherproof field logbook will be maintained by the FOL. The FOL or designee will record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events, field measurements, description of photographs, etc. The site logbook maintained by the FOL will contain a summary of the day's activities and will reference any additional field logbooks when applicable.

At the completion of field activities, the FOL will submit to the PM all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, etc. The PM will ensure that these materials are entered into the project file.

5.0 REPORTING

Following the completion of the field sampling and analytical work described in Section 3 of this work plan, the results of the information collected will be described in the form of a Focused Site Investigation (SI) report. The Focused SI report will contain seven major sections (detailed in the sections below), to reflect the general outline of a Remedial Investigation report.

It is the intent of the Navy to provide the draft report with a recommendation for or against continued actions of a (removal action, remedial investigation etc.). Such a recommendation will be based on the type, concentrations, and likely origins of chemicals that are found to exceed the risk based criteria. It is assumed that if the reviewers do not agree with the Navy's recommendation, a discussion can be held at that time to determine an agreeable course of action.

5.1 FOCUSED SI REPORT

Section 1.0 of the Focused SI report will describe the site history, background, and purpose of the report. The site background sections will include information from the Phase I Environmental Site Assessment of the Surface Warfare Officers School site that was published in July 2001 as well as from the Final Report and Risk Assessment for Worker Exposure at the SWOS Site. Any additional background information discovered during this investigation will be described in detail and incorporated into the site background section.

Section 2.0 of the Focused SI report will describe the site investigations which are the focus of this work plan. Specifically, this section will be based on Section 3.0 of this work plan and on the modifications of the field work, if any are made, during the period of activity.

Section 3.0 will describe the physical characteristics of the study area as they are observed at the time of the investigation. This will include the major site surface features (buildings, roadways, fences, etc). The site geology and hydrogeology will be described as determined by subsurface explorations performed. Figures will be prepared depicting aerial and/or cross sectional views of site features including: geology, maximum and minimum water table elevations and depth to bedrock. A shallow groundwater map will be created using water table elevations from both SWOS and OFFTA wells to help determine the groundwater flow direction in the area.

Section 4.0 of the Focused SI report will describe the contaminants found in various media during the investigations described in this work plan. This section will be based on the results of the activities described in Section 3.0 of this work plan and Section 2.0 of the Focused SI report. Summary tables of

analytical data will be included for all of the matrices sampled. During the field work, source areas identified or some of those originally targeted areas may be eliminated. All the chemical analytical data generated from the field work will be summarized in this section. Comparisons of soil analytical results will be made to background concentrations.

Figures to be included in Section 4.0 of the Focused SI report may include aerial and/or cross-sectional views of the site. As appropriate, pertinent information such as concentration of contaminants, location of samples, etc, will be included in the figures.

Section 5.0 of the Focused SI report will describe the expected transport mechanisms available to the primary site contaminants. This effort will focus on development of the first tiers of the conceptual site model presenting site contaminants, background conditions and contaminant fate. The conceptual model will be supported by discussion on the potential chemical and physical processes that influence movement and decomposition of site specific contaminants.

Section 6.0 will present the data assessment (see Section 5.2 of this work plan).

Section 7.0 of the Focused SI report will describe conclusions of the report. The conclusions of the Focused SI will be limited to an assessment of the presence or absence of site specific contaminants, discussion of a possible relationship of the adjacent OFFTA site (Site 09) to the SWOS site and a summary of exceedences of human health risk-based criteria (RBCs). Finally, a recommendation will be made regarding the need for or lack of a need for continuation of work at this site. If additional work is warranted, the recommendations will provide possible approaches such as removal actions or additional investigations.

5.2 DATA ASSESSMENT

Section 6.0 of the Focused SI report will consist of the data assessment as described below.

Chemical concentrations detected in soil will be compared with criteria including Region IX Residential Preliminary Remedial Goals (PRGs) (EPA, 2002), RIDEM Direct Exposure Criteria for Residential Soil (RIDEM, 2004), and background data set established for the adjacent OFFTA site (TtNUS, 2000). Chemical concentrations in groundwater will be compared with MCLs, Region IX PRGs for tap water (for comparison purposes only), and RIDEM criteria for GB groundwater, which is the classification for this site.

Contaminants detected will be eliminated as chemicals of potential concern (COPCs) at the site if the maximum concentration for the chemical is less than applicable screening criteria (groundwater and soil), and if the representative concentrations are below background concentrations (soil).

Chemicals that lack toxicity values will be evaluated qualitatively. The qualitative evaluation will include a discussion of the presence of the chemical at the specific sample stations where it was detected, a discussion of the toxicity of similar chemicals found at these stations or elsewhere at the site (if applicable, and a determination of impact of this chemical on the risk assessment results (i.e., will the omission of this chemical from a quantitative risk assessment, if one were performed, be significant or not).

Chemicals that are breakdown products of selected COPCs or chemicals that are in the same family as selected COPCs (e.g. carcinogenic PAHs and PCBs) will also be included as COPCs. The final list of COPCs will be provided for discussion regarding the need for further human health risk analysis.

A comparison to ecological screening benchmarks will not be performed as part of this focused site inspection. The majority of the site is covered either by the SWOS Applied Instruction Building or asphalt-paved parking which limit ecological exposure pathways.

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APPENDIX A

SITE SPECIFIC HEALTH AND SAFETY PLAN

(The Health and Safety Plan will be issued as a separate document)

APPENDIX B
TINUS STANDARD OPERATING PROCEDURES



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number

GH-2.8

Page

1 of 12

Effective Date

09/03

Revision

3

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Subject

GROUNDWATER MONITORING WELL INSTALLATION

Approved

D. Senovich

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 PROCEDURES	3
5.1 EQUIPMENT/ITEMS NEEDED	3
5.2 WELL DESIGN.....	3
5.2.1 Well Depth, Diameter, and Monitored Interval	3
5.2.2 Riser Pipe and Screen Materials.....	5
5.2.3 Annular Materials	6
5.2.4 Protective Casing	6
5.3 MONITORING WELL INSTALLATION.....	7
5.3.1 Monitoring Wells in Unconsolidated Sediments	7
5.3.2 Confining Layer Monitoring Wells.....	7
5.3.3 Bedrock Monitoring Wells	8
5.3.4 Drive Points	8
5.3.5 Innovative Monitoring Well Installation Techniques	8
5.4 WELL DEVELOPMENT METHODS	8
5.4.1 Overpumping and Backwashing	8
5.4.2 Surging with a Surge Plunger.....	9
5.4.3 Compressed Air	9
5.4.4 High Velocity Jetting.....	9
6.0 RECORDS	9
7.0 REFERENCES.....	10
 <u>ATTACHMENTS</u>	
A	RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT) / RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)..... 11
B	COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION..... 12

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 2 of 12
	Revision 3	Effective Date 09/03

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 3 of 12
	Revision 3	Effective Date 09/03

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 4 of 12
	Revision 3	Effective Date 09/03

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 5 of 12
	Revision 3	Effective Date 09/03

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8 Revision 3	Page 6 of 12 Effective Date 09/03
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5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium-to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 7 of 12
	Revision 3	Effective Date 09/03

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 8 of 12
	Revision 3	Effective Date 09/03

installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 9 of 12
	Revision 3	Effective Date 09/03

remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 10 of 12
	Revision 3	Effective Date 09/03

space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

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Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 11 of 12
	Revision 3	Effective Date 09/03

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

- | | | | |
|----|---------------------|---|------------------|
| 1 | Teflon* | 5 | Lo-Carbon Steel |
| 2 | Stainless Steel 316 | 6 | Galvanized Steel |
| 3. | Stainless Steel 304 | 7 | Carbon Steel |
| 4 | PVC 1 | | |

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton**	Silicone	Neoprene	Teflon**
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

- | | | | |
|----|------------------------|---|------------------------|
| 1 | Teflon* | 5 | PE Conventional |
| 2 | Polypropylene (PP) | 6 | Plexiglas/Lucite (PMM) |
| 3. | PVC Flexible/PE Linear | 7 | Silicone/Neoprene |
| 4 | Viton* | | |

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Source: Barcelona et al., 1983

Subject GROUNDWATER MONITORING WELL INSTALLATION	Number GH-2.8	Page 12 of 12
	Revision 3	Effective Date 09/03

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	GH-2.5	Page	1 of 9
Effective Date	06/99	Revision	1
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>DS</i>		

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	3
5.0 PROCEDURES	3
5.1 POTENTIOMETRIC SURFACE MAPPING	3
5.1.1 Selection of Wells	3
5.1.2 Water Level Measurements	3
5.1.3 Construction of Equipotential Lines	4
5.1.4 Determination of Groundwater-Flow Direction	4
5.2 GROUNDWATER FLOW CONSIDERATIONS	5
5.3 DETERMINATION OF FLOW RATE	5
6.0 REFERENCES	7

ATTACHMENTS

A	GENERALIZED POROSITY AND HYDRAULIC CONDUCTIVITY VALUES FOR GEOLOGIC MATERIALS	9
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Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	<table> <tr> <td> Number GH-2.5 </td><td> Page 2 of 9 </td></tr> <tr> <td> Revision 1 </td><td> Effective Date 06/99 </td></tr> </table>	Number GH-2.5	Page 2 of 9	Revision 1	Effective Date 06/99
Number GH-2.5	Page 2 of 9				
Revision 1	Effective Date 06/99				
1.0 PURPOSE	<p>The purpose of this procedure is to provide a basic understanding of developing contour maps and the approaches used to identify and quantify the direction and rate of groundwater flow and contaminant plume movement.</p>				
2.0 SCOPE	<p>This procedure provides only a general overview of the field techniques, mathematical and physical relationships and data handling procedures used for determining groundwater flow direction and rate. The references identified herein can provide a more complete explanation of particular methods cited, as well as a more comprehensive discussion on the interpretation of hydrogeologic data.</p>				
3.0 GLOSSARY	<p><u>Aquifer</u> - A geologic formation capable of transmitting usable quantities of groundwater to a well or other discharge point.</p> <p><u>Aquitard</u> - A geologic formation which retards the flow of groundwater due to its low permeability.</p> <p><u>Confined Aquifer</u> - An aquifer that is overlain and underlain by zones of lower permeability (aquitards). If the aquifer is "artesian," the potentiometric head of the aquifer at a given point is higher than the top of the zone comprising the aquifer at that point.</p> <p><u>Equipotential Line</u> - A line connecting points of equal elevation of the water table or potentiometric surface. Equipotential lines on the water table are also called water table contour lines.</p> <p><u>Flow Line</u> - A flow line indicates the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.</p> <p><u>Flow Net</u> - A diagram of groundwater flow showing flow lines and equipotential lines.</p> <p><u>Hydraulic Conductivity (K)</u> - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid.</p> <p><u>Hydraulic Gradient (i)</u> - The rate of change of hydraulic head per unit distance of flow at a given point and in the downgradient direction.</p> <p><u>Hydraulic Head</u> - The height to which water will rise inside a well casing, equal to the elevation head plus the pressure head. In a well screened across the water table, hydraulic head equals the elevation head, as the pressure head equals 0. In wells screened below the water table in an unconfined aquifer or screened at any interval within a confined aquifer, the head is the sum of the elevation of the aquifer (the elevation head) and the fluid pressure of the water confined in the aquifer (the pressure head).</p> <p><u>Potentiometric (piezometric) Surface</u> - A hypothetical surface that coincides with the static level of the water in an aquifer (i.e., the maximum elevation to which water will rise in a well or piezometer penetrating the aquifer). The term "potentiometric surface" is usually applied to confined aquifers, although the water table is the potentiometric surface of an unconfined aquifer.</p> <p><u>Unconfined Aquifer</u> - An aquifer in which the water table forms the upper boundary.</p>				

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 3 of 9
	Revision 1	Effective Date 06/99

Water Table - The surface in the groundwater system at which the fluid pressure is equal to atmospheric pressure (i.e., the net pressure head is zero) and below which all strata are saturated with water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist (with the concurrence of the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - All supporting field personnel must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

5.0 PROCEDURES

5.1 Potentiometric Surface Mapping

5.1.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day, preferably within 2-3 hours. This is especially important when working in an area where groundwater levels are tidally influenced or influenced by pumping.

The recorded water levels, monitoring-well construction data, site geology, and topographic setting must be reviewed to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this determination. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow; information from many more wells are needed to provide an accurate contour map. Generally, shallow systems require data from more wells than deep systems for accurate contour mapping. Potentiometric surface mapping for shallow flow systems also requires water level measurements from nearby surface water bodies.

5.1.2 Water Level Measurements

After selection of the wells to be used for mapping, the next step in determining the direction of groundwater flow is to obtain water level elevations from the selected points. In addition, any other readily available wells/surface water bodies should be measured to ensure that sufficient data are available for interpretation purposes.

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5 Revision 1	Page 4 of 9 Effective Date 06/99
<p>Elevations are obtained from measurements of the depth to water in a monitoring well or piezometer taken from the top of the well casing (see SOP GH-1.2) and then referencing the elevation of the casing to a chosen and consistent datum point, usually mean sea level. Subtracting the depth to water from the casing elevation provides the elevation of the potentiometric surface. Elevations of points and areas of groundwater discharge or recharge such as springs, seeps, streams, rivers, and lakes also need to be determined, typically through staff gauge measurements. Comparison of these elevations, which represent hydraulic heads, will reveal the direction of flow because groundwater flows from areas of high head to areas of low head.</p> <p>5.1.3 Construction of Equipotential Lines</p> <p>Graphical methods available for depicting the flow of groundwater include the use of equipotential lines and flow lines to construct potentiometric surface maps and vertical flow nets. If the hydrogeologic system consists of a water table aquifer and one or more confined aquifers, separate contour maps should be prepared for each aquifer system. Water table maps should be developed using water level measurements obtained from monitoring wells screened at the unsaturated-saturated interface. Water level measurements collected from monitoring wells screened in the deeper portions of an unconfined aquifer should generally be contoured as a separate potentiometric surface map. Surface water discharge or recharge features are contoured in the water table system. Vertical flow nets should be constructed using a cross section aligned parallel to the direction of groundwater flow. All water level measurements along this cross section, both deep and shallow, are used in developing equipotential lines and flow lines for the flow net.</p> <p>To construct equipotential lines, water level elevations in the chosen wells are plotted on a site map. Other hydrogeologic features associated with the zone of interest – such as seeps, wetlands, and surface-water bodies – should also be plotted along with their elevations.</p> <p>The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is the most commonly used technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful rough mapping of large data sets; however, final, detailed mapping must <u>always</u> be performed by hand by an experienced hydrogeologist. Contour lines shall be drawn as smooth, continuous lines which never cross one another.</p> <p>Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted utilizing the professional judgment of the hydrogeologist in accordance with these features. Closed contours should be avoided unless a known groundwater sink (i.e., pumping well) or mound exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must be evident in the contour plot.</p> <p>5.1.4 Determination of Groundwater-Flow Direction</p> <p>Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions (i.e., wells) will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.</p>		

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 5 of 9
	Revision 1	Effective Date 06/99

5.2 Groundwater Flow Considerations

Groundwater movement is an integral part of the hydrologic cycle. Recharge to the shallow groundwater environment generally occurs by infiltration of precipitation through an upper unsaturated soil zone. Movement is downward under the force of gravity until the water reaches the saturated zone of the water table aquifer. Once water is part of the water table aquifer, movement is controlled by differences in hydraulic head, with movement from areas of high head to areas of low head. Areas of low head include natural discharge areas such as springs, lakes, rivers, and, ultimately, the ocean. These features can be considered as outcrops of the water table. Points of low head also are created by pumping wells.

Local head differences and consequent vertical flow patterns within an aquifer can be detected by well clusters. A well cluster consists of several adjacent wells, generally installed within a few feet of each other, and screened at different depths. Variations in water levels in these closely spaced wells indicate the vertical component of groundwater flow within an aquifer, provided that the wells are all screened within the same aquifer.

The number, location, and extent of geologic units and their properties with regard to aquifer or aquitard characteristics must be understood to properly interpret water level data gathered from the monitoring system. This firm understanding of the hydrogeologic system must be developed through a program of borings, wells, and interpretation of subsurface geology. The adequacy of the positions and depths of borings/wells used to define relevant subsurface hydrogeologic conditions must also be assessed. The location of surface water discharge or recharge points must be considered. Surface water features influence the system, as flow is most likely toward them (if they are discharge points) or away from them (if they are recharge points). Man-made discharge or recharge features such as pumping or injection wells, ditches, and trenches can also affect the flow of groundwater.

5.3 Determination of Flow Rate

Darcy's Law states that the quantity of water flowing through a geologic material is dependent upon the permeability of the material, the hydraulic gradient, and the cross sectional area through which the water flows. This relation is expressed in the equation:

$$Q = KiA$$

where:

- Q = volume of water flowing through the cross sectional area of the formation (L^3/T).
- K = hydraulic conductivity (L/T).
- i = hydraulic gradient (L/L , i.e., dimensionless).
- A = cross sectional area of formation being considered (L^2).

The relation is similar to one used in stream flow measurements where:

$$Q = VA$$

where:

- Q = discharge from the cross sectional area of a stream or pipe (L^3/T).
- V = average velocity of flowing water (L/T).
- A = cross sectional area through which water flows (L^2).

Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 6 of 9
	Revision 1	Effective Date 06/99

The velocity of water movement in a geologic formation depends on the specific formation properties and the head differences across the formation. This relation is defined in the equation:

$$V = \frac{Ki}{n}$$

where:

V = average linear velocity of groundwater through the formation (L/T)
K = hydraulic conductivity (L/T)
i = hydraulic gradient (dimensionless)
n = porosity (expressed as a fraction).

Values of porosity for several geologic materials are given in Attachment A. More accurate and specific values of porosity can be obtained by laboratory analysis of a formation sample or from an unconfined aquifer pumping test.

Hydraulic conductivity is related to the permeability of the formation and depends on the size and interconnection of the pore spaces. In isotropic and homogeneous formations, the hydraulic conductivity will be the same vertically and horizontally. In anisotropic formations, horizontal and vertical conductivity can be markedly different and the vertical hydraulic conductivity can be up to several orders of magnitude lower than the horizontal hydraulic conductivity. Typically, most formations are anisotropic with horizontal hydraulic conductivities at least several times as high as the vertical hydraulic conductivities.

Generally, hydraulic conductivities are high for sands, gravels, and limestone containing large solution cavities and low for silts, clays, and tightly fractured rock. Attachment A gives values of hydraulic conductivity for several geologic materials. More accurate values can be obtained during field testing of aquifers or from laboratory measurements on undisturbed cores. Results from field testing usually provide higher (and more representative) hydraulic conductivities than laboratory testing because full-scale field testing includes the effects of the formational macrostructure (i.e., secondary permeability due to jointing or fractures) which is not reflected in the testing of a small sample in the laboratory.

The hydraulic gradient, *i*, is determined from field measurements of hydraulic head obtained from water level measuring points. Do not measure gradient from well to well; measure across equipotential lines that are drawn based on the well (and other) data. Once a potentiometric surface map has been generated using the hydraulic head data, the hydraulic gradient can be calculated using the following formula:

$$i = \frac{dh}{dl}$$

where:

dh = change in head (L)
dl = distance between equipotential lines (L)

The hydraulic gradient along any flow line can be calculated from a potentiometric surface map by dividing the change in head by the length of the flow line, typically beginning and ending at equipotential lines. The longer the distance over which the head change is measured, the more representative the gradient is of overall conditions.

Subject	Number GH-2.5	Page 7 of 9
GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Revision 1	Effective Date 06/99

When chemical solutes are traveling in groundwater, as in cases of groundwater contamination, the calculated groundwater velocity may predict migration rates in excess of what is actually observed. The difference in chemical versus water velocities may be due to attenuation or biodegradation of the chemical species in the aquifer. Attenuation is most often caused by adsorption of the chemical contaminant onto the formation grains or matrix. The result is that the chemical does not appear at the downgradient sampling point as quickly as the velocity calculation predicts. An equation to correct for this attenuation is:

$$V_c = V_w / (1 + K_d P_b / n)$$

where:

V_c	=	velocity of the chemical solute flow (L/T)
V_w	=	velocity of groundwater flow (L/T)
P_b	=	formation mass bulk density (M/L ³)
n	=	formation porosity (expressed as a fraction)
K_d	=	distribution coefficient = (L ³ /M)

The K_d is equal to the mass of solute per unit mass of solid phase divided by the concentration of solute in solution. The term in the denominator is known as the retardation factor.

Density and/or viscosity differences between water and contaminants can also cause velocity determination errors. Light hydrocarbons such as gasoline are less dense than water and consequently float on the water table. These contaminants can migrate along the water table surface at rates faster or slower than the rate of groundwater movement, depending on specific conditions, and may also volatilize into unsaturated soil pore spaces. Oils are more viscous than water and will typically migrate more slowly due to the viscosity difference. Contaminants denser than water such as heavy hydrocarbons (e.g., coal tar) or chlorinated compounds (e.g., TCE, PCE) tend to sink to the bottom of an aquifer if present in concentrations exceeding their solubility limit (these chemicals are often referred to as dense, nonaqueous phase liquids, or DNAPLs if present as a separate-phase liquid). Here, the contamination may move at faster or slower rates than the overlying groundwater or may actually move in a direction opposite to that of the groundwater, depending on the geologic characteristics of the aquifer base and direction of dip of the underlying aquitard.

Other factors involving the physicochemical interaction between the chemical and the groundwater, such as dilution (mixing contaminated water or chemicals with additional quantities of groundwater) and dispersion (molecular diffusion of the chemical throughout the groundwater regime), can also affect the observed rates of travel of contaminants in groundwater. In addition to such physicochemical characteristics, all of the aquifer and aquitard properties and groundwater flow characteristics described above must be known so that adequate and accurate estimations of the extent and rate of groundwater contaminant migration can be developed.

6.0 REFERENCES

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Subject	Number	Page
GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	GH-2.5	8 of 9
	Revision	Effective Date
	1	06/99

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Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS	Number GH-2.5	Page 9 of 9
	Revision 1	Effective Date 06/99

ATTACHMENT A

GENERALIZED POROSITY AND HYDRAULIC CONDUCTIVITY VALUES FOR GEOLOGIC MATERIALS

Material	Porosity Range (%)	Hydraulic Conductivity Range	
		cm/sec	ft/day
Gravel	30-40	10^{-1} to 10^{-2}	280 to 2.8×10^5
Coarse sand (clean)	30-40	10^{-1} to 1	280 to 2,800
Medium sand (clean)	35-45	10^{-2} to 10^{-1}	28 to 280
Fine sand (clean)	40-50	5×10^{-4} to 10^{-2}	1.4 to 28
Silty sand	25-40	10^{-5} to 10^{-2}	0.03 to 280
Glacial Till	Variable	10^{-10} to 10^{-4}	3×10^{-7} to 0.3
Unweathered Clay/Shale	45-55 (clay)	10^{-7} to 10^{-4}	3×10^{-4} to 0.3 (horizontal)
		10^{-10} to 10^{-6}	3×10^{-7} to 3×10^{-3} (vertical)
Karst Limestone	—	10^{-4} to 10^{-1}	0.3 to 2,800
Fractured Igneous/Metamorphic Rocks	—	10^{-6} to 10^{-1}	3×10^{-3} to 280
Sandstone	5-30	10^{-8} to 10^{-4}	3×10^{-5} to 0.3

Source: References 1 and 2



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	SA-2.5	Page	1 of 6
Effective Date	09/03	Revision	3
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>ds</i>		

Subject DIRECT PUSH TECHNOLOGY
(GEOPROBE®/HYDROPUNCH™)

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 SOIL SAMPLING PROCEDURES	3
5.1 GENERAL	3
5.2 SAMPLING EQUIPMENT	3
5.3 DPT SAMPLING METHODOLOGY	3
6.0 GROUNDWATER SAMPLING PROCEDURES	4
6.1 GENERAL	4
6.2 SAMPLING EQUIPMENT	4
6.3 DPT TEMPORARY WELL POINT INSTALLATION AND SAMPLING METHODOLOGY	5
7.0 RECORDS	5
 <u>ATTACHMENTS</u>	
1 SAFE WORK PERMIT	6

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 2 of 6
	Revision 3	Effective Date 09/03

1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 3 of 6
	Revision 3	Effective Date 09/03

Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.
- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.
- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.
- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.
- Place the acetate liner containing the soils in the trough.

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 4 of 6
	Revision 3	Effective Date 09/03

- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.
- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.
- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).
- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 5 of 6
	Revision 3	Effective Date 09/03

6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.
- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.
- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (± 10 percent), the well may be sampled.
- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.
- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).
- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)	Number SA-2.5	Page 6 of 6
	Revision 3	Effective Date 09/03

**ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS**

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

- I. Work limited to the following (description, area, equipment used): Monitoring well drilling and installation through direct push technology
- II. Required Monitoring Instruments: _____
- III. Field Crew: _____
- IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

- V. Protective equipment required Respiratory equipment required
- | | | |
|--|--|--|
| Level D <input checked="" type="checkbox"/> Level B <input type="checkbox"/> | Full face APR <input type="checkbox"/> | Escape Pack <input type="checkbox"/> |
| Level C <input type="checkbox"/> Level A <input type="checkbox"/> | Half face APR <input type="checkbox"/> | SCBA <input type="checkbox"/> |
| Detailed on Reverse | SKA-PAC SAR <input type="checkbox"/> | Bottle Trailer <input type="checkbox"/> |
| | Skid Rig <input type="checkbox"/> | None <input checked="" type="checkbox"/> |

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

- VI. Chemicals of Concern _____ Action Level(s) _____ Response Measures _____

VII. Additional Safety Equipment/Procedures

- | | |
|---|--|
| Hard-hat <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Safety Glasses <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Chemical/splash goggles <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Splash Shield <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Barricades <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Splash suits/coveralls <input type="checkbox"/> Yes <input type="checkbox"/> No | Gloves (Type - _____) <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Steel toe Work shoes or boots <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Work/warning regimen <input type="checkbox"/> Yes <input type="checkbox"/> No |

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors

- | | | | | | |
|--|-------------------------------------|-------------------------------------|-------------------------|--------------------------|--------------------------|
| | Yes | NA | | Yes | NA |
| Safety shower/eyewash (Location & Use)..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> | Emergency alarms | <input type="checkbox"/> | <input type="checkbox"/> |
| Daily tail gate meetings..... | <input checked="" type="checkbox"/> | <input type="checkbox"/> | Evacuation routes | <input type="checkbox"/> | <input type="checkbox"/> |
| Contractor tools/equipment/PPE inspected | <input type="checkbox"/> | <input type="checkbox"/> | Assembly points | <input type="checkbox"/> | <input type="checkbox"/> |

IX. Site Preparation

- | | |
|---|--|
| Utility Clearances obtained for areas of subsurface investigation | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Physical hazards removed or blockaded | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Site control boundaries demarcated/signage | <input type="checkbox"/> Yes <input type="checkbox"/> No |

X. Equipment Preparation

- | | | |
|--|--------------------------|-------------------------------------|
| | Yes | NA |
| Equipment drained/depressurized..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Equipment purged/cleaned..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Isolation checklist completed..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Electrical lockout required/field switch tested | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Blinds/misalignments/blocks & bleeds in place | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Hazardous materials on walls/behind liners considered..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> |

- XI. Additional Permits required (Hot work, confined space entry). ☐ Yes ☐ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

Permit Issued by: _____ Permit Accepted by: _____



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number
SA-6.3

Page
1 of 12

Effective Date
09/03

Revision
2

Applicability
Tetra Tech NUS, Inc.

Prepared
Earth Sciences Department

Subject
FIELD DOCUMENTATION

Approved
D. Senovich *DS*

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 PROCEDURES	2
5.1 SITE LOGBOOK	2
5.1.1 General.....	2
5.1.2 Photographs	3
5.2 FIELD NOTEBOOKS	3
5.3 FIELD FORMS	4
5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results..	4
5.3.2 Hydrogeological and Geotechnical Forms	5
5.3.3 Equipment Calibration and Maintenance Form.....	6
5.4 FIELD REPORTS.....	6
5.4.1 Daily Activities Report.....	6
5.4.2 Weekly Status Reports.....	7
6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS.....	7

ATTACHMENTS

A	TYPICAL SITE LOGBOOK ENTRY	9
B	SAMPLE LABEL.....	10
C	CHAIN-OF-CUSTODY RECORD FORM.....	11
D	CHAIN-OF-CUSTODY SEAL	12

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 2 of 12
	Revision 2	Effective Date 09/03

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 3 of 12
	Revision 2	Effective Date 09/03

that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strik mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 4 of 12
	Revision 2	Effective Date 09/03

5.3 Field Forms

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (<http://intranet.ttnus.com>) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 5 of 12
	Revision 2	Effective Date 09/03

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

5.3.2 **Hydrogeological and Geotechnical Forms**

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 6 of 12
	Revision 2	Effective Date 09/03

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used as the project directs each time a QA sample is collected, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 7 of 12
	Revision 2	Effective Date 09/03

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at <http://intranet.ttnus.com> under Field Log Sheets.

6.0 **LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. [HTTP://INTRANET.TTNUS.COM](http://intranet.ttnus.com) CLICK ON FIELD LOG SHEETS**

Groundwater Sample Log Sheet
 Surface Water Sample Log Sheet
 Soil/Sediment Sample Log Sheet
 Container Sample and Inspection Sheet
 Geochemical Parameters (Natural Attenuation)
 Groundwater Level Measurement Sheet
 Pumping Test Data Sheet
 Packer Test Report Form
 Boring Log
 Monitoring Well Construction Bedrock Flush Mount
 Monitoring Well Construction Bedrock Open Hole
 Monitoring Well Construction Bedrock Stick Up
 Monitoring Well Construction Confining Layer
 Monitoring Well Construction Overburden Flush Mount
 Monitoring Well Construction Overburden Stick Up
 Test Pit Log
 Monitoring Well Materials Certificate of Conformance
 Monitoring Well Development Record

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 8 of 12
	Revision 2	Effective Date 09/03

Daily Activities Record
Field Task Modification Request
Hydraulic Conductivity Test Data Sheet
Low Flow Purge Data Sheet
QA Sample Log Sheet
Equipment Calibration Log
Field Project Daily Activities Checklist
Field Project Pre-Mobilization Checklist

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 9 of 12
	Revision 2	Effective Date 09/03

**ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY**

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL: _____

TINUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE


ACTIVITIES:

1. Steam jerney and fire hoses were set up.
2. Drilling activities at well _____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page _____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit _____ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

Field Operations Leader

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 10 of 12
	Revision 2	Effective Date 09/03

ATTACHMENT B

 Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project: Site: Location:	
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:		Laboratory:	

Subject

FIELD DOCUMENTATION

Number

SA-6.3

Page

11 of 12

Revision
2Effective Date
09/03

ATTACHMENT C



TETRA TECH NUS, INC.

CHAIN OF CUSTODY

NUMBER 3413

PAGE ____ OF ____

PROJECT NO:		FACILITY:		PROJECT MANAGER		PHONE NUMBER		LABORATORY NAME AND CONTACT:											
SAMPLERS (SIGNATURE)				FIELD OPERATIONS LEADER		PHONE NUMBER		ADDRESS											
				CARRIER/WAYBILL NUMBER		CITY, STATE													
STANDARD TAT <input type="checkbox"/> RUSH TAT <input type="checkbox"/> <input type="checkbox"/> 24 hr. <input type="checkbox"/> 48 hr. <input type="checkbox"/> 72 hr. <input type="checkbox"/> 7 day <input type="checkbox"/> 14 day				TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS	CONTAINER TYPE PLASTIC (P) or GLASS (G)										
DATE YEAR	TIME	SAMPLE ID	LOCATION ID						PRESERVATIVE USED										
<div>TYPE OF ANALYSIS</div> <div>COMMENTS</div>																			
1. RELINQUISHED BY				DATE	TIME	1. RECEIVED BY				DATE	TIME								
2. RELINQUISHED BY				DATE	TIME	2. RECEIVED BY				DATE	TIME								
3. RELINQUISHED BY				DATE	TIME	3. RECEIVED BY				DATE	TIME								
COMMENTS																			

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE)

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4/02R
FORM NO. TINUS-001

019611/P

Tetra Tech NUS, Inc.

Subject FIELD DOCUMENTATION	Number SA-6.3	Page 12 of 12
	Revision 2	Effective Date 09/03

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

Signature <hr/>		CUSTODY SEAL
Date <hr/>		Date <hr/>
CUSTODY SEAL		Signature <hr/>



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number

SA-6.1

Page

1 of 11

Effective Date

02/04

Revision

3

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Subject

NON-RADIOLOGICAL SAMPLE HANDLING

Approved

D. Senovich

TABLE OF CONTENTS

SECTION

PAGE

1.0	PURPOSE.....	2
2.0	SCOPE.....	2
3.0	GLOSSARY	2
4.0	RESPONSIBILITIES.....	3
5.0	PROCEDURES.....	3
5.1	SAMPLE CONTAINERS.....	3
5.2	SAMPLE PRESERVATION.....	3
5.2.1	Overview	4
5.2.2	Preparation and Addition of Reagents	4
5.3	FIELD FILTRATION.....	5
5.4	SAMPLE PACKAGING AND SHIPPING.....	6
5.4.1	Environmental Samples	6
6.0	REFERENCES.....	7

ATTACHMENTS

A	GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS.....	8
B	ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES	9

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 2 of 11
	Revision 3	Effective Date 02/04

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H₂SO₄
- Nitric Acid - HNO₃
- Sodium Hydroxide - NaOH

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 3 of 11
	Revision 3	Effective Date 02/04

Other Preservatives

- Zinc Acetate
- Sodium-Thiosulfate - $\text{Na}_2\text{S}_2\text{O}_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 4 of 11
	Revision 3	Effective Date 02/04

changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO₃, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H ₂ SO ₄)	1 part concentrated H ₂ SO ₄ : 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO ₃)	Undiluted concentrated HNO ₃	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 5 of 11
	Revision 3	Effective Date 02/04

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.
- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).
- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

Continue with proper base preservation of the sample as described above.
- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

The sample pH is then raised to 9 using the NaOH preservative.
- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 6 of 11
	Revision 3	Effective Date 02/04

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.
- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TiNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)
- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.
- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.
- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.
- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).
- Seal (i.e., tape or tie top in knot) large liner bag.
- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.
- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 7 of 11
	Revision 3	Effective Date 02/04

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 8 of 11
	Revision 3	Effective Date 02/04

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
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WATER

Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days ⁽⁹⁾
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO ₃ to pH ≤ 2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH > 12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days

SOIL

Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction, 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorga nic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction

AIR

Volatile Organics	Low/Medium		Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended
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1 All glass containers should have Teflon cap liners or septa.

2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 9 of 11
	Revision 3	Effective Date 02/04

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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INORGANIC TESTS:

Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid ⁽⁵⁾	14 days ⁽⁶⁾
Fluoride	P	None required	28 days
Hardness	P, G	HNO ₃ to pH 2; H ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H ₂ SO ₄ to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 10 of 11
	Revision 3	Effective Date 02/04

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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INORGANIC TESTS (Cont'd):

Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours

METALS:⁽⁷⁾

Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO ₃ to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO ₃ to pH 2	6 months

ORGANIC TESTS:⁽⁸⁾

Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days
Phenols ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Benzidines ^{(11),(12)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction ⁽¹³⁾
Phthalate esters ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines ^{(11),(14)}	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
PCBs ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs) ^{(11),(14)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Haloethers ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF) ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction

Subject NON-RADIOLOGICAL SAMPLE HANDLING	Number SA-6.1	Page 11 of 11
	Revision 3	Effective Date 02/04

**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE THREE**

- (1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
- (2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
- (3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
- (4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
- (5) Should only be used in the presence of residual chlorine.
- (6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
- (7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
- (8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
- (9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
- (10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
- (11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
- (12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
- (13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
- (14) For the analysis of diphenylnitrosamine, add 0.008% Na₂S₂O₃ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
- (15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na₂S₂O₃.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number

SA-1-1

Page

1 of 25

Effective Date

09/03

Revision

5

Applicability

Tetra Tech NUS, Inc.

Prepared

Earth Sciences Department

Subject

GROUNDWATER SAMPLE ACQUISITION AND
ONSITE WATER QUALITY TESTING

Approved

D. Senovich *[Signature]*

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE.....	2
2.0 SCOPE.....	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES.....	2
5.0 PROCEDURES.....	3
5.1 GENERAL	3
5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT.....	4
5.3 CALCULATIONS OF WELL VOLUME	4
5.4 EVACUATION OF STATIC WATER (PURGING)	5
5.4.1 General.....	5
5.4.2 Evacuation Devices.....	5
5.5 ONSITE WATER QUALITY TESTING.....	6
5.5.1 Measurement of pH.....	7
5.5.2 Measurement of Specific Conductance	9
5.5.3 Measurement of Temperature	10
5.5.4 Measurement of Dissolved Oxygen	11
5.5.5 Measurement of Oxidation-Reduction Potential.....	12
5.5.6 Measurement of Turbidity.....	13
5.5.7 Measurement of Salinity.....	14
5.6 SAMPLING	15
5.6.1 Sampling Plan	15
5.6.2 Sampling Methods.....	16
5.7 LOW FLOW PURGING AND SAMPLING	17
5.7.1 Scope & Application	17
5.7.2 Equipment	17
5.7.3 Purging and Sampling Procedure	18
6.0 REFERENCES.....	20
 <u>ATTACHMENTS</u>	
A PURGING EQUIPMENT SELECTION.....	21
B GROUNDWATER SAMPLE LOG SHEET.....	24
C LOW FLOW PURGE DATA SHEET	25

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 2 of 25
	Revision 5	Effective Date 09/03

1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 3 of 25
	Revision 5	Effective Date 09/03

Project Geologist/Field Sample Technician - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.
2. For wells that can be purged dry, the well shall be evacuated and allowed to recover to 75% full capacity prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
 - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.
 - The intake line of the sampling pump (or the submersible pump itself) unless otherwise directed shall be placed near the center of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e.,

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 4 of 25
	Revision 5	Effective Date 09/03

floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), water level indicator.
- Pumps
 - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.
 - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or inner casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).
- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 5 of 25
	Revision 5	Effective Date 09/03

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)1$

where: V = Static volume of well in gallons.
T = Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r = Inside radius of well casing in inches.
0.163 = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 6 of 25
	Revision 5	Effective Date 09/03

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation-Reduction Potential (ORP)

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 7 of 25
	Revision 5	Effective Date 09/03

- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP 6.3 for example equipment calibration log.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydron paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 8 of 25
	Revision 5	Effective Date 09/03

- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).
- Buffer solutions, as specified by the manufacturer.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 9 of 25
	Revision 5	Effective Date 09/03

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance. Most conductivity meters in use today display specific conductance (SC); units of milliSiemens per centimeter, which is the conductivity normalized to temperature @ 25°C. This format (SC) is the required units recorded on the groundwater sample log field form (Attachment B).

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 10 of 25
	Revision 5	Effective Date 09/03

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity.
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 11 of 25
	Revision 5	Effective Date 09/03

5.5.4 Measurement of Dissolved Oxygen

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH⁻) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 12 of 25
	Revision 5	Effective Date 09/03

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 13 of 25
	Revision 5	Effective Date 09/03

measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Combination meters with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be checked using the manufacturer's recommended reference solution and have its batteries checked before going to the field.
- Thoroughly rinse the electrode with deionized water.
- If the probe does not respond properly to the recommended reference solution, then verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.
- Record all pertinent information on an equipment calibration log sheet.

5.5.6 Measurement of Turbidity

5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 14 of 25
	Revision 5	Effective Date 09/03

natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Light meter (e.g., LaMotte 2020) which calibrates easily using test cells with standards of 0.0 NTUs, and 10 NTUs, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the electrode with one or more portions of the sample to be tested or with deionized water (applies to "e").
- Fill the light meters glass test cell with ~5 ml of sample, screw on cap, wipe off glass, place test cell in light meter and close the lid (applies to "l").
- Immerse the electrode in the sample and measure the turbidity (applies to "e").
- The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode or test cell with deionized water.

5.5.7 Measurement of Salinity

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 15 of 25
	Revision 5	Effective Date 09/03

temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 600 series).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 16 of 25
	Revision 5	Effective Date 09/03

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see Attachment B); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket or cylinder and stopwatch are most commonly used.
7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 17 of 25
	Revision 5	Effective Date 09/03

10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.
12. Fill sample containers (preserve and label as described in SOP SA-6.1).
13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 18 of 25
	Revision 5	Effective Date 09/03

- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Interface probe, if needed.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP, salinity, and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (see Attachments B and C).
- Sample Bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Open monitoring well, measure head space gases using PID/FID. If there is an indication of off gassing when opening the well, wait 3-5 minutes to permit water level an opportunity to reach equilibrium.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

Start with the initial pump rate set at approximately 0.1 liters/minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below

Subject	GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number	SA-1-1	Page	19 of 25
		Revision	5	Effective Date	09/03

the top of the well screen, purging will cease or the well will be pumped to dryness and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be collected from these wells within the same workday and no later than 24 hours after the start of purging.

Measure the well water level using the water level meter every 5 to 10 minutes. Record the well water level on the Low-Flow Purge Data Form (Attachment C).

Record on the Low-Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, dissolved oxygen and salinity or as specified by the approved site specific work plan) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

After stabilization is achieved, sampling can begin when a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ± 0.2 standard units
- Specific conductance $\pm 10\%$
- Temperature $\pm 10\%$
- Turbidity less than 10 NTUs
- Dissolved oxygen $\pm 10\%$

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 20 of 25
	Revision 5	Effective Date 09/03

6.0 REFERENCES

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Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING	Number SA-1-1	Page 21 of 25
	Revision 5	Effective Date 09/03

ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Vitor®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
 PP Polypropylene
 PVC Polyvinyl chloride
 SS Stainless steel
 PC Polycarbonate
 EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

AC Not applicable
 DC Alternating current
 DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

Subject
 GROUNDWATER SAMPLE
 ACQUISITION AND ONSITE
 WATER QUALITY TESTING

Number
 SA-1-1
 Revision
 5

Page
 23 of 25
 Effective Date
 09/03

**GROUNDWATER SAMPLE
ACQUISITION AND ONSITE
WATER QUALITY TESTING**

SA-1-1

25 of 25

CT

Effective Date
09/03

ATTACHMENT C
LOW FLOW PURGE DATA SHEET



PROJECT SITE NAME: _____
PROJECT NUMBER: _____

WELL ID.: _____
DATE: _____

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SIGNATURE(S): _____

PAGE__OF__



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number

ME-15

Page

1 of 20

Effective Date

06/99

Revision

1

Applicability

Tetra Tech NUS, Inc.

Prepared

Health Sciences Department

Subject PHOTOVAC MICROFID HANDHELD
FLAME IONIZATION DETECTOR

Approved

D. Senovich

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 PURPOSE	2
2.0 SCOPE	2
3.0 GLOSSARY	2
4.0 RESPONSIBILITIES	2
5.0 PROCEDURES	3
5.1 GENERAL	3
5.2 USE AND DOCUMENTATION OF RESULTS	3
5.3 PRINCIPLES OF OPERATION	3
5.4 CALIBRATION	10
5.5 ROUTINE MAINTENANCE	11
5.5.1 Battery Charging	11
5.5.2 Emptying the Hydrogen Cylinder	12
5.5.3 Replacing the Sample Inlet Filter	12
5.6 TROUBLESHOOTING	13
5.6.1 MicroFID Fault Messages	13
5.7 TRANSPORTING MICROFID	18
6.0 SHIPPING	18
7.0 REFERENCES	18

FIGURES

<u>NUMBER</u>	<u>PAGE</u>
5-1 DOCUMENTATION OF FIELD CALIBRATION	4
5-2 DIRECT-READING INSTRUMENT RESPONSE DATA	5
5-3 BORING LOG	7
5-4 TEST PIT LOG	8
6-1 EXAMPLE OF A HAZARDOUS AIRBILL FOR HYDROGEN	19
6-2 EXAMPLE OF A HAZARDOUS AIRBILL FOR METHANE IN AIR	20

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15 Revision 1	Page 2 of 20 Effective Date 06/99
<p>1.0 PURPOSE</p> <p>To establish procedures for the use, calibration, maintenance, troubleshooting, and shipment of the Photovac MicroFID handheld flame ionization detector.</p> <p>2.0 SCOPE</p> <p>Applies to all Brown & Root Environmental personnel who operate the MicroFID instrument during the performance of their work.</p> <p>3.0 GLOSSARY</p> <p>None.</p> <p>4.0 RESPONSIBILITIES</p> <p><u>Office Managers</u> - Office Managers are responsible for ensuring that personnel under their direction who may use this device are first provided with adequate training and information</p> <p><u>Project Managers</u> - Project Managers are responsible for ensuring that appropriate health and safety requirements and resources are addressed for their assigned projects.</p> <p><u>Health and Safety Manager (HSM)</u> - The HSM shall ensure that appropriate training is available to users of the Photovac MicroFID instrument.</p> <p><u>Equipment Manager</u> - The Equipment Manager shall ensure that all air monitoring instrumentation slated for field activities has been operationally checked out, fully charged, and calibrated prior to issuance for field service. Maintenance deficiencies identified by the Equipment Manager will require those instruments to be pulled from service until repairs can be facilitated.</p> <p><u>Field Operations Leader (FOL)/Field Team Leader (FTL)</u> - The FOL/FTL shall ensure all field team members using monitoring instruments as part of their assigned duties are adequately trained in their proper operation and limitations. The FOL/FTL shall ensure that the air monitoring instruments are employed as directed by site guidance documents (i.e., Work Plan, Health and Safety Plan, etc.). Additionally, the FOL/FTL shall ensure that the appropriate documentation and recordkeeping requirements are fulfilled including Documentation of Calibration and Direct Reading Instrument Response Data Sheets for air monitoring activities. On projects where a dedicated SSO is not assigned, the FOL/FTL is responsible for assuming the duties of that position.</p> <p><u>Health and Safety Officer (HSO)</u> - The HSO is responsible for determining air monitoring requirements for the site activities, and providing direction for air monitoring during specific site activities. This identification of types of air monitoring and direction for use are indicated within the Site-Specific Health and Safety Plan (HASP).</p> <p><u>Site Safety Officer (SSO)</u> - The SSO shall ensure the instruments identified are employed in the manner directed by the HSO and action levels employed as contingencies marks for the application of engineering controls, personal protective equipment (PPE) use, and administrative controls are employed as directed. Additionally, he/she shall ensure the instruments are properly maintained and calibrated prior to use in the field. The SSO during specific air monitoring applications including STEL and TWA mode measurements will be responsible for operation and application of this specialty air monitoring employment duty. The</p>		

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 3 of 20
	Revision 1	Effective Date 06/99

SSO is also responsible for addressing relevant Hazard Communication requirements (e.g., MSDS, chemical inventories, labeling, training, etc.) on each assigned project.

5.0 PROCEDURES

5.1 General

Direct-reading instruments such as a flame ionization detector are typically used to monitor for airborne releases that could present an inhalation threat to personnel, and to screen and bias environmental samples. Proper use of these instruments by trained, qualified personnel is essential to the validity of any acquired results. Also essential is that the devices are properly calibrated according to manufacturers instructions (and the specifications of this SOP), and that users of the instrument properly document results.

5.2 Use and Documentation of Results

As with any direct-reading instrument, understanding not only how - but when to use this instrument is essential to gathering relevant and valid data. This device will only respond to volatile organics in air that are combustible. Inappropriate instrument selection, use, or interpretation of instrument results by an unqualified user not only can yield inaccurate results, but could place personnel at risk of exposure to hazardous agents. Only personnel who are properly trained and authorized to use this device will be permitted to operate it.

It is essential that instrument operators understand and comply with the requirements to document results. This includes the need to document calibration results as well as operational readings. Calibration results must be recorded using Figure 5-1. Operational results can be recorded in several ways, including:

- Direct-Reading Instrument Response Data (Figure 5-2) - preferred method
- Boring Log Forms (Figure 5-3)
- Test Pit Log Forms (Figure 5-4)
- Log book entries

When using direct-reading instruments, it is important to monitor the air near the source of potential releases (e.g., drilling boreholes, tank entrances, drum openings, etc.) and at worker breathing zone areas. All readings should be recorded, including readings noted where background levels were not exceeded.

5.3 Principles of Operation

The MicroFID is a flame ionization detector used for the measurement of combustible organic compounds in air at parts per million levels. Permanent air gases (argon, carbon dioxide, nitrogen, oxygen, water vapor, etc.) are not ionized by the flame.

When the MicroFID is turned on, the display prompts you to turn on the hydrogen. The internal pump draws sample air in through MicroFID's inlet. This sample air provides the oxygen necessary for combustion in the hydrogen-fueled flame. When the proper ratio of hydrogen to air is present in the combustion chamber, the flame is automatically started with a glow plug. A thermocouple is used to monitor the status of the flame. When the sample passes through the flame the combustible organic compounds in the sample will be ionized. After the compounds have been ionized, they are subjected to

DOCUMENTATION OF FIELD CALIBRATION

PROJECT NO.: _____

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DIRECT-READING INSTRUMENT RESPONSE DATA

PAGE OF

[illegible]

**PHOTOVAC MICROFID HANDHELD
FLAME IONIZATION DETECTOR**

Number

ME-15

Page

6 of 20

Revision

Effective Date

06/99

FIGURE 5-2 (Continued)

SITE NAME: _____

PROJECT NO.: _____

PAGE _____ OF _____

[illegible]



Page ____ of ____

TEST PIT CROSS SECTION AND / OR PLAN VIEW

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Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 9 of 20
	Revision 1	Effective Date 06/99

a continuous electric field between the repeller electrode at the jet and the collector electrode. The ions in the electric field generate a current which is proportional to the concentration of the ionized molecules in the ionization chamber. An electrometer circuit converts the current to a voltage that is then fed to the microprocessor which interprets the current in units of ppm. After the sample passes through the flame and has become ionized, it is vented from the detector through a flame arrestor. The flame arrestor prevents the flame from igniting any flammable gases present in the working atmosphere.

MicroFID is strictly an organic compound detector. It does not respond to inorganic compounds. MicroFID's sensitivity is highly dependent on chemical structure and bonding characteristics. The combustion efficiency of a compound determines its sensitivity. Simple saturated hydrocarbons (methane, ethane, etc.) possess high combustion efficiencies and are among the compounds that produce the highest MicroFID response. Organic fuels (acetylene, refined petroleum products), burn easily and are also extremely well detected.

The presence of substituted functional groups (amino, hydroxyl, halogens) on a simple hydrocarbon reduces its combustion efficiency and the MicroFID's sensitivity to the compound. For example, methanol and chloromethane are detectable with MicroFID, but not at the same sensitivity as methane. The number of carbon atoms can also affect the instrument's sensitivity due to substitution. For example, MicroFID is more sensitive to n-butanol than it is to methanol. For additional information regarding response factors of the MicroFID, consult the manufacturer's of the User's Manual.

Beginning Operation

The MicroFID can be operated without the activation of the flame to print or review logged data. In this way, the hydrogen fuel is conserved.

MicroFID will attempt to ignite the flame once the flow of hydrogen gas has been started. If the MicroFID has not been used for a while, it is possible that the gas supply lines are filled with air. If the flame cannot be started, MicroFID will begin a 30 second purge cycle. During the purge cycle it will flush the gas supply lines with hydrogen. After the purge cycle, it will attempt to light the flame again. If it fails again, another purge cycle will be performed and MicroFID will try a third time to ignite the flame. The following steps summarize proper start-up procedures.

1. Turn the instrument on by pressing the front of the On/Off switch. When the instrument is powered up, the version number and creation date of the instrument software are displayed. Press ENTER.
2. You will be prompted to start the flame. If you do not want to start the flame, use the ARROW keys to select "No Flame Needed" and press ENTER. To start the flame, use the ARROW keys to select Start Flame and press ENTER.
3. If you selected "Start Flame," MicroFID will prompt you to turn on the hydrogen. Turn the shut-off valve counterclockwise to start the flow of hydrogen and press ENTER.
4. The pump will start and MicroFID will then ignite the flame. You will hear a small pop when the flame has been ignited. Once the flame has been started the message "Detector flame has been started OK" will be displayed followed by the default display.

The default display provides the following information: instrument status, current detected concentration, event name (if the datalogger is on), time, and date. If an event name is longer than three characters, the bottom line of the display will scroll through the information.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 10 of 20
	Revision 1	Effective Date 06/99

The instrument status appears at the left of the upper line of the display and on the Print and Graph outputs. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

5.4 Calibration

The calibration (CAL) key is used to calibrate MicroFID. Before beginning calibration, ensure that you have a reliable source of both zero air and calibration gas. To document calibration efforts, field personnel will record information on the Documentation of Field Calibration Form (Figure 5-1), or the same information in the calibration/maintenance log book assigned to an instrument. A brief description of the functions under the CAL key are as follows:

1. When you press the CAL key you will first be prompted to select a Cal Memory. Each Cal Memory stores a unique zero point, sensitivity setting, response factor and alarm level.
2. You will then be prompted to enter a response factor. Refer to the manufacturer's User's Manual for a list of response factors. If the compound is not listed in that reference, or if you are measuring gas mixtures, enter a value of 1.00. The concentration detected by MicroFID will be multiplied by the response factor before it is displayed and logged.
3. Next select Low Range or High Range operation. Use Low Range if you are sampling concentrations between 0.5 and 2000 ppm (methane equivalents). Use High Range if you are sampling concentrations between 10 and 50,000 ppm (methane equivalents).
4. You will now be prompted to connect a supply of zero air. You may use ambient air or, for best results, use a clean Tedlar bag filled with zero grade air. In most cases, ambient air will be used provided calibration is performed in an area in which interfering airborne contaminants are not present. If using ambient air, press <ENTER> to begin zeroing.
5. If you are using a charcoal filter to clean ambient air, connect the filter by loading the Teflon ferrules into the nut (the ferrules and the nut are supplied with the filter). Connect the nut to MicroFID's inlet. Do not tighten the nut. Remove the charcoal filter from its plastic bag and insert it into the nut. Finger tighten the nut onto the inlet. If the filter is not secure, ensure you have inserted the tube far enough into the nut. Do not over-tighten the fitting. Press <ENTER> and the MicroFID will set its zero point. NOTE: The charcoal filter does not filter methane or ethane. If these compounds are present, use a gas bag with a supply of commercial zero air.
6. If you are using a Tedlar bag filled with zero air, connect the bag to the inlet. Open the bag and press <ENTER>. MicroFID will set its zero point.
7. After MicroFID has set its zero point, you can then enter the concentration of the calibration gas (span gas), and then connect the Tedlar bag adapter to the inlet. Open the bag and press <ENTER>. MicroFID sets its sensitivity. Note: You must have a supply of calibration gas ready before calibrating MicroFID. When calibrating MicroFID, ensure the instrument is level. If MicroFID is tilted from side to side, gravity will affect the flame height and cause erroneous readings.
8. When MicroFID's display reverts to normal, it is calibrated and ready for use. Remove the Tedlar bag from the inlet.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 11 of 20
	Revision 1	Effective Date 06/99

9. Press the ALARM key and enter the alarm level for the selected CAL memory.

5.5 Routine Maintenance

5.5.1 Battery Charging

A fully charged battery will power the MicroFID for approximately 15 hours. If the instrument is to be used for more than 15 hours, carry a spare battery pack. Battery life is reduced if the instrument is turned off and then on again repeatedly.

When the instrument status displays "LoBat," the battery pack requires changing. When the "LoBat" status is displayed, you have a few minutes of operation left. MicroFID will turn itself off before the battery pack becomes critically low.

To remove the battery pack:

1. Stop the flow of hydrogen gas by turning the hydrogen shut-off valve fully clockwise. Turn the instrument off by pressing the On/Off switch twice.
2. Use the MicroFID multi-tool to loosen the two captive screws in the bottom of the battery pack.
3. A retainer at the rear of the instrument helps secure the battery pack to the instrument. Free the battery pack from the instrument.
4. Connect the charged battery pack to the retainer at the rear of the instrument.
5. Retighten the two captive screws and the bottom of the battery pack.

To charge the battery pack:

1. Ensure the correct plug is installed on the line cord of the battery charger.
2. Plug the charger into the jack located on the front of the battery pack.
3. Plug the charger into an AC outlet. The LED, on the battery pack indicates the charge state. Red indicates the battery is being charged. Green indicates the battery is fully charged and ready for use. It is normal for a fully charged battery to indicate it is charging (red light) when first plugged in. The LED will turn green as the battery charges.
4. When the battery pack is charged remove the charger, first from the wall outlet then from the battery pack.

Charging a fully discharged battery pack will take approximately 8 hours. Leaving the charger connected to a charged battery pack will not harm the battery or the charger in any way. If a battery pack is to be left indefinitely, leave it connected to the charger so that it will be fully charged and ready for operation.

5.5.2 Emptying the Hydrogen Cylinder

When you transport the MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 12 of 20
	Revision 1	Effective Date 06/99

To empty the cylinder:

1. Take the instrument outdoors, or to a well-ventilated area, at least 25 feet from any potential sources of ignition.
2. Turn the MicroFID off and open the hydrogen shut-off valve.
3. Remove the battery pack as described above.
4. Locate the purge outlet. It is located on the underside of the instrument.
5. Use the MicroFID multi-tool to turn the screws counterclockwise. Loosen the screw but do not remove it.
6. Leave the instrument so that the purge outlet is facing up. If the purge outlet is facing down, hydrogen will vent into MicroFID's case.
7. If the cylinder is full, it will take approximately 15 minutes to empty.
8. Watch the Contents gauge. When the cylinder is empty, close the purge outlet. Use the MicroFID multi-tool to turn the screw clockwise.
9. Replace the battery pack as discussed above.

5.5.3 Replacing the Sample Inlet Filter

MicroFID is equipped with a combined dust and water filter to reduce detector contamination. As the filter collects dust, MicroFID's inlet flow rate and sensitivity decrease. The filter will not allow water to pass through, but the filter will not stop gases and vapors.

Replace the filter on a weekly basis, or more frequently if MicroFID is used in a dusty or wet environment. You must replace the filter if MicroFID has been exposed to liquid water. The pump will sound labored when the filter requires replacement.

1. Turn off the instrument and unscrew the filter housing from the detector housing. Be careful not to lose the o-ring seal.
2. Remove the Teflon/Polypropylene filter and install the new filter. Place the filter in the filter housing with the Teflon side facing down into the filter housing and the mesh side facing the MicroFID. Handle the filter disk only by the edges. The mesh may be damaged or contaminated by excessive handling. Use forceps if possible.
3. Replace the filter housing.
4. Calibrate the CAL Memories that you are using before continuing operation.

5.6 Troubleshooting

This section provides guidance for troubleshooting the MicroFID. If problems are not corrected through these troubleshooting methods, contact the Photovac Service Department.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 13 of 20
	Revision 1	Effective Date 06/99

5.6.1 MicroFID Fault Messages

When the "Check" status is displayed, MicroFID's operation is compromised. Press the <TUTOR> key for a two-line description of the fault. One exception is the flame out fault. When a flame out fault occurs, the instrument status changes to "NoFlm."

Fault: Detector flame has gone out.

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the cylinder purge outlet has been closed.

Cause: Oxygen supply is deficient (Note: This is a Level B PPE condition).

Action: Ensure there is an adequate supply of oxygen. If you are sampling very high concentrations it is possible you are sampling above the flame out concentration. The flame out concentration for methane is approximately 52,000 ppm (5.2 percent methane in air).

A minimum of 17 percent oxygen is required to start the hydrogen flame. The oxygen is supplied from the sample as it is drawn in by the pump. A minimum of 10 percent oxygen is required to maintain the hydrogen flame.

Flame out also may occur when sampling enclosed or confined spaces where vapors and gases cannot escape. Watch for indications of increased flame height such as erratic readings or sudden high concentrations followed by a flame out fault.

If you will be using the MicroFID in a highly contaminated area where it is possible that the oxygen content will fall below 10 percent, watch for indication of reduced flame height such as lowered detection limits or a flame out fault.

Cause: High concentrations of flammable gases (gases within their flammable range) are present. High concentrations of flammable gases can act as an additional fuel source. When this happens, the flame height may increase beyond the confines of the combustion chamber. The hydrogen supply will then be cut-off and the flame will go out. Monitor LEL conditions and observe action levels specified in the Health and Safety Plan.

Action: Move to a location where there is an adequate supply of air and restart the flame. See the information above. Watch for indications of increased flame height such as erratic readings or sudden height concentrations followed by a flame out fault.

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor, a by-product of the hydrogen flame, may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 14 of 20
	Revision 1	Effective Date 06/99

Cause: Sample line is blocked

Action: Ensure the sample line is not obstructed in any way. If you are using the long sample probe, ensure flow is maintained through the entire length of tubing.

Cause: Inlet filter is plugged.

Action: Replace the inlet filter.

Fault: Signal from zero gas is too high.

Cause: Contamination of sample line or fittings before the detector.

Action: Clean or replace the sample line of the inlet filter.

Cause: Span gas is used instead of zero gas.

Action: Ensure clean gas is used to zero the MicroFID. Mark the calibration and zero gas Tedlar bags clearly.

Cause: Ambient air is contaminated.

Action: If you are unsure about the quality of the ambient air, use a charcoal filter or a supply of commercial zero grade air.

Cause: Hydrogen supply is contaminated.

Action: Hydrogen may react with the carbon element of the steel tank to produce methane. This will only occur if the cylinder is in poor condition and if the hydrogen has a high moisture content. Replace the hydrogen tank. Empty and refill the MicroFID internal cylinder with fresh hydrogen.

Fault: Signal from the calibration gas is too small

Cause: Calibration gas and zero air are switched.

Action: Ensure calibration gas is used to calibrate the MicroFID. Mark the calibration and zero gas Tedlar bags clearly. Ensure the calibration gas is of a reliable concentration.

Fault: Detector field voltage is low.

Cause: Internal fault in electronics.

Action: Contact the Photovac Service Department.

Problem: No instrument response detected, yet compounds are known to be present.

Cause: MicroFID has not been calibrated properly.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 15 of 20
	Revision 1	Effective Date 06/99

Action: Ensure calibration gas is of a reliable concentration and then calibrate the instrument. After the instrument has been calibrated, sample the Tedlar bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the Photovac Service Department.

Action: When calibrating the MicroFID, ensure the instrument is level. If the MicroFID is tilted side to side, gravity can affect the flame height and cause erroneous readings. If the sampling location is difficult to reach without tilting the instrument, use the long sample probe.

Cause: Background contamination from the hydrogen.

Action: It is possible that the hydrogen has become contaminated and is contributing a high background signal. If the hydrogen supply tank is more than 6 months old it should be replaced with a new cylinder. When ordering hydrogen, specify ultra-high purity (99.999 percent pure). Empty the MicroFID hydrogen cylinder (as described in Section 5.5.2 of this SOP) and then refill with hydrogen from the new cylinder.

Problem: **Date and time settings are not retained.**

Cause: MicroFID has not been used for 3 months or more and the internal battery (not the external battery pack) has been discharged.

Action: Turn MicroFID on and allow it to run until a "LoBat" status appears. This will take approximately 15 hours. Remove the battery pack and recharge it overnight. Repeat this procedure for 3 or 4 days. While MicroFID is running the internal battery is charging.

Problem: **Cannot fill the internal hydrogen cylinder to 1800 psi.**

Cause: Supply tank has less than 1800 psi of pressure. You can only fill the internal cylinder to a pressure of less than or equal to the tank pressure.

Action: Fill the internal cylinder to the pressure of the tank or replace the tank with a full one.

Cause: The hydrogen purge outlet is open.

Action: Close the outlet and fill the cylinder.

Cause: There is a problem with the refill adapter.

Action: Contact the Photovac Service Department

Problem: **Instrument status shows "Over."**

Cause: Rapid change in signal level. The detector electronics have been momentarily saturated.

Action: Wait a few seconds for the status to return to "Ready."

Cause: The detector has become saturated.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 16 of 20
	Revision 1	Effective Date 06/99

Action: Move the MicroFID to a location where it can sample clean air. Sample zero air until the reading stabilizes around "0." If you were using Low Range, switch to High Range. Calibrate the CAL Memory you were using when the "Over" status appeared.

Problem: **Display contrast bars are on or display is blank.**

Cause: Battery pack is critically low.

Action: Recharge the battery pack or connect the MicroFID to the battery charger.

Cause: The battery pack is not connected to the instrument properly.

Action: Ensure the battery pack has been aligned correctly. Ensure the battery pack is secured by the retainer at the rear of the instrument.

Problem: **Sample flow rate varies from 600 ml/min. +/-10 percent.**

Cause: Inlet filter has not been installed.

Action: Install an inlet filter.

Cause: Inlet filter has not been properly tightened onto the detector cap.

Action: Finger-tighten the filter cap.

Cause: Inlet filter is plugged.

Action: Replace the inlet filter.

Cause: Pump has been damaged.

Action: Contact the Photovac Service Department

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Problem: **Flame will not ignite.**

Cause: The hydrogen gas has run out.

Action: Ensure the shut-off valve is open. Check the hydrogen contents gauge on the side of the instrument and refill the hydrogen cylinder if necessary. Ensure the hydrogen purge outlet is closed.

Cause: Oxygen supply is deficient.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 17 of 20
	Revision 1	Effective Date 06/99

Action: Ensure there is an adequate supply of oxygen. Do not attempt to ignite the flame in a location where there is the suspicion of encountering greater than 10,000 ppm methane or the equivalent concentration of a flammable gas. Move to a location where there are lower concentrations, start the flame and then begin sampling higher concentrations. Monitor for LEL conditions, following action levels specified in the Health and Safety Plan. If the flame goes out while you are sampling very high concentrations, it is possible you are sampling above the flame out concentration. The flame out concentration of methane is approximately 52,000 ppm (5.2 percent methane in air). A minimum of 17 percent oxygen is required to start the hydrogen flame. Oxygen is supplied from the sample as it is drawn in by the pump. A minimum of 10 percent oxygen is required to maintain the hydrogen flame.

Cause: Exhaust port is blocked.

Action: At low temperatures, water vapor (a by-product of the hydrogen flame) may condense at the exhaust port. At sub-zero temperatures the water will freeze and obstruct the exhaust port. If the exhaust port becomes obstructed, pump operation will be inhibited. Flame out may also result. Operate the MicroFID within the operating temperature range 41 to 105 degrees Fahrenheit. In the event that the flame arrestor becomes clogged, contact the Photovac Service Department.

Cause: Hydrogen supply lines are full of air.

Action: If MicroFID has not been operated for some time, it is possible that the hydrogen supply lines contain air. Fill the hydrogen cylinder and then open the hydrogen shut-off valve. Allow the hydrogen to purge the system for about 5 minutes and then turn MicroFID on and start the flame.

Cause: Hydrogen lines are blocked.

Action: Contact the Photovac Service Department.

Problem: **Liquid has been aspirated.**

Cause: MicroFID has been exposed to a solvent that can pass through the Teflon/Polypropylene filter.

Action: Contact the Photovac Service Department.

5.7 Transporting MicroFID

When you transport MicroFID, you should empty the internal hydrogen cylinder and then refill it when you arrive at your destination (see Section 5.5.2 of this SOP). If you are traveling by passenger aircraft, you **must** empty the hydrogen cylinder. You cannot transport MicroFID by passenger aircraft with hydrogen in the cylinder.

The MicroFID can be shipped to sites. However, if shipment is to be performed while the cylinder still contains hydrogen, a Hazardous Materials Airbill must be filled out and the package must be properly marked and labeled. Examples of various completed forms are provided as Figures 6-1 and 6-2.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 18 of 20
	Revision 1	Effective Date 06/99

6.0 SHIPPING

The Photovac may be shipped as cargo or carried on as luggage providing there is no hydrogen fuel source or calibration gas cylinder accompanying the kit. **Only personnel who have been properly trained are permitted to offer a hazardous material for shipment.** The "Shipping Hazardous Materials" course offered by Tetra Tech NUS is considered acceptable training for this purpose. Specific instructions on packaging, labeling, and otherwise preparing a hazardous material shipment are presented in the Student Manual that accompanies the course. If shipping or transporting the hydrogen fuel source, a Hazardous Materials (or Dangerous Goods) Airbill such as the example in Figure 6-1 must be completed. When shipping or transporting the calibration gas, a separate Airbill (such as the one illustrated in Figure 6-2) must be prepared.

7.0 REFERENCES

MicroFID Handheld Flame Ionization Detector User's Manual, 1995.

Student Manual from "Shipping Hazardous Materials" course, Tetra Tech NUS, 1999.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 19 of 20
	Revision 1	Effective Date 06/99

FIGURE 6-1

EXAMPLE HAZARDOUS AIRBILL FOR HYDROGEN

FedEx *Dangerous Goods* **Sender's Copy**
2887300 *Airbill* RETAIN THIS COPY FOR YOUR RECORDS
7180827

1 From (please print and press hard)
Date _____ Sender's FedEx Account Number _____
Sender's Name _____ Phone (____) _____
Company _____
Address _____
City _____ State _____ ZIP _____
2 Your Internal Billing Reference Information (Optional) (Print 20 characters with spaces as needed)
3 To (please print and press hard)
Recipient's Name **TBM PATTON** Phone **(412) 262 4583**
Company **TETRA TECH NUS**
Address **SPRING RUN RD EXT STE 140 B 1** Check here if residence (We Cannot Deliver to P.O. Boxes or R.D. ZIP Codes) Dept./Room/Club/Room
City **CORACPOLIS** State **PA** ZIP **15108**
City _____ State _____ ZIP _____
4 Express Package Service Packages under 100 lbs.
☐ FedEx Priority Overnight (Next business morning) ☐ FedEx Standard Overnight (Next business day)
☐ FedEx 2Day (Second business day) ☐ FedEx Express Saver (Third business day)
5 Express Freight Service Packages over 100 lbs.
☐ FedEx Overnight Freight (Next business day) ☐ FedEx Express Saver Freight (Third business day)
(Call for delivery schedule. Some restrictions apply. See back for detailed descriptions of freight services.)

The World On Time. +

Service Conditions, Restricted Areas, and Limited Liability - By using this bill, you agree to the service conditions in our latest Service Guide or U.S. Government Service Rules. Both are available on request. SEE BACK OF SENDER'S COPY OF THIS AIRBILL FOR INFORMATION AND ADDITIONAL TERMS. We will not be responsible for any loss in excess of \$100 per package unless we are notified, through filing a claim, of the actual loss or damage, within 90 days of the date of shipment, and with some limitations, refund of transportation charges.

Questions? Call 1-800-Go-FedEx® (800)463-3339

5 Packaging
☒ Other Packaging
Dangerous Goods cannot be shipped in FedEx packaging.

6 Special Handling
☒ Dangerous Goods as per Restricted Shipper's Declaration ☒ Cargo Aircraft Only

7 Payment
Bill to: ☐ Sender ☐ Recipient ☐ Third Party ☐ Credit Card ☐ Cash
Pay to: ☐ Sender ☐ Recipient ☐ Third Party ☐ Credit Card ☐ Cash
Public Account No. _____
Total Packages _____ Total Weight _____ Total Declared Value \$ _____
When declaring a value higher than \$100 per shipment, you pay a declared value fee. SEE BACK OF SENDER'S COPY OF THIS AIRBILL FOR INFORMATION AND ADDITIONAL TERMS.

Signature Release Unavailable

807286973876 0204

Page 1 of 1 Pages

TRANSPORT DETAILS
This shipment is subject to the Hazardous Materials Regulations (49 CFR 173.101-173.160).
Airport of Departure: _____
Airport of Destination: _____
Nature and Quantity of Dangerous Goods: **Hydrogen Compressed**
Class or Division: **2.1**
UN or ID No.: **UN 1049**
Packing Group: _____
Subsidiary Risk: _____
Quantity and Type of Packaging: **1 Plastic Box 1.0 Kg**
Packing Unit: **200**
Authorization: _____
Additional Handling Information: _____
Prepared for AIR TRANSPORT according to: (Customer MUST check one)
☐ 49 CFR ☒ ICAO / IATA

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

Emergency Telephone Number (Required for US Shipper or Destination Shipments)
1-800-535-5053 Infortrac

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

Subject PHOTOVAC MICROFID HANDHELD FLAME IONIZATION DETECTOR	Number ME-15	Page 20 of 20
	Revision 1	Effective Date 06/99

FIGURE 6-2

EXAMPLE HAZARDOUS AIRBILL FOR METHANE IN AIR

FedEx <i>Dangerous Goods</i> 7181160 <i>Airbill</i> Sender's Copy RETAIN THIS COPY FOR YOUR RECORDS		<i>The World On Time</i>																	
From (please print and press hard) Date _____ Sender's FedEx Account Number _____ Sender's Name _____ Phone _____ Company _____ Address _____ Dept./Floor/Suite/Room _____ City _____ State _____ ZIP _____																			
2 Your Internet Billing Reference Information (Optional) (Print 24 characters with asterisk as invalid) 3 To (please print and press hard) Recipient's Name Tom Patton Phone (412) 262-4583 Company Tetra Tech NUS Address Spring Run Road Extension, Suite 140 Check here if residence (Mark charge account for FedEx billing) City Coraopolis State PA ZIP 15108																			
For HOLD at FedEx Location check here <input type="checkbox"/> Hold Weekday <input type="checkbox"/> Hold Saturday (not available at all locations) (Mark for FedEx Priority Overnight and FedEx 2Day only) For WEEKEND Delivery check here <input type="checkbox"/> Saturday Delivery (available for FedEx Priority Overnight and FedEx 2Day only) <input type="checkbox"/> NEW Sunday Delivery (available for FedEx Priority Overnight only)		5 Packaging <input checked="" type="checkbox"/> Other Packaging Dangerous Goods cannot be shipped in FedEx packaging.																	
4a Express Package Service Packages under 100 lbs. <input type="checkbox"/> FedEx Priority Overnight (Next business day) <input type="checkbox"/> FedEx Standard Overnight (Next business day) <input type="checkbox"/> FedEx 2Day (Second business day) <input type="checkbox"/> FedEx Express Saver (Third business day)		6 Special Handling <input checked="" type="checkbox"/> Dangerous Goods as per attached Shipper's Declaration <input type="checkbox"/> Cargo Aircraft Only																	
4b Express Freight Service Packages over 100 lbs. <input type="checkbox"/> FedEx Overnight Freight (Next business day) <input type="checkbox"/> FedEx 2Day Freight (Second business day) <input type="checkbox"/> FedEx Express Saver Freight (Third business day)		7 Payment Bill to: <input type="checkbox"/> Sender (Account No. is shown) <input type="checkbox"/> Recipient <input type="checkbox"/> Third Party <input type="checkbox"/> Credit Card <input type="checkbox"/> Cash/Check FedEx Account No. _____ Credit Card No. _____ Total Packages _____ Total Weight _____ Total Declared Value \$ _____ Total Charges \$ _____																	
Signature Release Unavailable (PART 11422) + Rev. Date 4/98 807286974806 0204																			
Page 1 of 1 Pages Two completed and signed copies of this Declaration must be handed to the operator.																			
TRANSPORT DETAILS This shipment is subject to the regulations prescribed in: (Select one) PASSENGER AIRCRAFT <input checked="" type="checkbox"/> CARGO AIRCRAFT <input type="checkbox"/> Airport of Departure: _____ Airport of Destination: _____		WARNING Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent. Shipment type: (Select one) <input checked="" type="checkbox"/> NON-RADIOACTIVE <input type="checkbox"/> RADIOACTIVE																	
NATURE AND QUANTITY OF DANGEROUS GOODS <table border="1"> <thead> <tr> <th>Proper Shipping Name</th> <th>Class or Division</th> <th>UN or ID No.</th> <th>Packing Group</th> <th>Subsidiary Risk</th> <th>Quantity and Type of Packaging</th> <th>Packing Inst.</th> <th>Authorization</th> </tr> </thead> <tbody> <tr> <td>Compressed Gas N.O.S. (mixture Nitrogen and Oxygen)</td> <td>2.2</td> <td>UN 1956</td> <td></td> <td></td> <td>1 Plastic box x 0.56 Kg</td> <td>200</td> <td></td> </tr> </tbody> </table>				Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization	Compressed Gas N.O.S. (mixture Nitrogen and Oxygen)	2.2	UN 1956			1 Plastic box x 0.56 Kg	200	
Proper Shipping Name	Class or Division	UN or ID No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization												
Compressed Gas N.O.S. (mixture Nitrogen and Oxygen)	2.2	UN 1956			1 Plastic box x 0.56 Kg	200													
Additional Handling Information Prepared for AIR TRANSPORT according to: (Customer MUST check one) <input type="checkbox"/> CFR <input checked="" type="checkbox"/> ICAO / IATA																			
I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. Emergency Telephone Number (Required for US Origin or Destination Shipments) 1-800-535-5053 InfoTRAC IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT																			

**STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Division of Groundwater and Individual Sewage Disposal Systems**

**Rules and Regulations for
GROUNDWATER QUALITY**



August 1996

Promulgated:	May 1992
Amended:	July 1993
	May 1995
	August 1996

Regulation 12-100-006

AUTHORITY: These Rules and Regulations are adopted in accordance with Chapter 42-35 pursuant to Chapters 46-12, 46-13.1, 23-18.9, 23-19.1, 42-17.6 and 42-17.1 of the Rhode Island General Laws of 1956, as amended

APPENDIX 1

Required Monitoring Well Construction Standards and Abandonment Procedures

- 1.0 Purpose: to provide minimum standards for; (a) the procurement of samples representative of groundwater; and (b) abandonment procedures for removing the vertical conduit to groundwater.
- 2.0 Applicability: The monitoring well construction standards herein apply to all permanent monitoring wells installed pursuant to these regulations. Pursuant to Rule 12.02 of these regulations, wells installed at the direction of other programs are exempt from Rules 4.0 through 12.0 of this Appendix. A monitoring well is designated permanent if it exists for more than 180 days. Rule 13 of this Appendix on monitoring well abandonment applies to all permanent and non-permanent monitoring wells subject to these regulations. Rule 13 also applies to those piezometers where improper abandonment would result in a reasonable likelihood of groundwater pollution. Additional requirements may be specified by the Director.
- 3.0 Prevention of Groundwater Pollution: During well construction and abandonment, every appropriate precaution shall be taken to prevent introducing pollutants into the groundwater. This shall include, but not be limited to, steam cleaning and washing of drilling equipment and proper cleaning and storage of well casing. Only potable water shall be used in well construction and abandonment unless otherwise approved by the Director.
- 4.0 Construction and Abandonment Standards: The procedures described in this Appendix incorporate minimum standards. The Director may waive the requirements and allow deviation from these procedures where such deviations are necessary to procure representative groundwater samples. All deviations from the procedures shall be documented and provided to the Director. If the Director determines that the deviation from these procedures will not or does not result in the procurement of samples representative of groundwater, the Director may require the installation of a new monitoring well.
- 5.0 Well Casing: All permanent groundwater monitoring wells shall be constructed of PVC well casing material. All casing shall have a minimum inside diameter of 2.0 inches. Monitoring wells constructed in unconsolidated material less than 100 feet in depth shall be constructed using a minimum of schedule 40 PVC. Wells greater than 100 feet shall be constructed using a minimum of schedule 80 PVC.
- 5.1 Assembly and Installation: All casing shall be constructed of flush threaded joints or threaded coupling joints. All joints shall be fitted with an "O" ring or wrapped with teflon tape. Solvent welded joints are not permissible without prior written permission of the Director.
- 5.2 Exceptions: The Director may allow alternate well casing material if the pollutant concentrations or geologic setting require an alternative construction. Alternative materials include but are not limited to: (a) Teflon; (b) stainless steel; or (c) uncoated or galvanized steel.
- 6.0 Well Screen: The well screen slot size shall retain at least 90% of the grain size of a filter pack or at least 60% of the grain size of the collapsed formation. Well screens on wells and piezometers shall not exceed the length necessary to collect a representative groundwater sample or to determine water table elevation. Well screens shall be factory slotted. A bottom cap and sump sediment trap shall be installed.
- 7.0 Filter Pack: The filter pack shall be chemically inert, well rounded and well sorted glass beads or silica-based sand or gravel of uniform grain size. The filter pack must minimize the amount of fine material entering the well and shall not inhibit the flow of water into the well. The filter pack shall extend a minimum of one foot, but no more than 5 feet above the well screen. The filter pack shall not pollute groundwater.

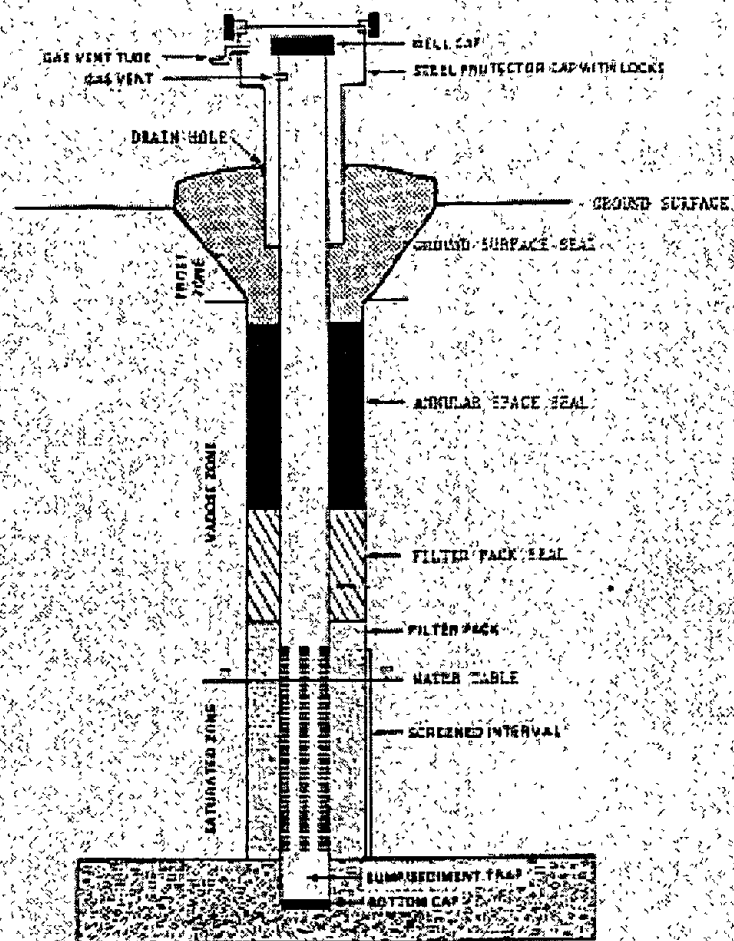
8.0 Sealing Requirements

- 8.1 Filter Pack Seal: All monitoring wells installed with a filter pack shall be constructed with a filter pack seal, such as bentonite flakes or pellets. The seal shall extend to approximately one foot above the filter pack and shall be properly hydrated.
- 8.2 Annular Space Seal: All monitoring wells shall be installed with an annular space seal that has a permeability of 1×10^{-7} centimeters per second or less. Materials that meet this criterion include but are not limited to neat cement grout and cement-bentonite grout. The annular space seal shall extend to the ground surface seal, except where a road box meeting the requirements of Rule 10.0 of this Appendix is used.
- 8.3 Ground Surface Seal: All monitoring wells shall be constructed with a continuous pour concrete ground surface seal. To avoid frost heaving and to anchor the well, the ground surface seal shall extend to a minimum of 40 inches below the land surface, unless the well meets one of the requirements of the exemption described in Rule 8.4 of this Appendix. The ground surface seal shall be flared such that the diameter at the top is greater than the diameter at the bottom. The top of the ground surface seal shall be sloped away from the well casing and shall be imprinted with the designation of the monitoring well.

8.4 Exemption from 40 Inch Ground Surface Seal Requirement: As stated in Rule 8.3 of this Appendix, the ground surface seal shall extend at least 40 inches down the hole from the land surface. Exemptions from this rule are limited to the following circumstances: 1) where the seal would interfere with proper placement or functioning of the well screen; and 2) where a road box is used and sand is placed inside and directly below the road box in such a way as to ensure that any seepage into the road box drains away from the well.

- 9.0 Protective Cover Pipe: The protective pipe shall consist of a minimum 4 inch diameter metal casing with locking cap. The protective pipe shall extend from the bottom of the ground surface seal to a minimum of 24 inches above the land surface. There shall be no more than 4 inches between the top of the well casing and the top of the protective pipe. The monitoring well designation shall be indicated clearly on the protective cover pipe. A gas vent and a drain hole shall be installed. A high visibility guard post to prevent destruction of the well may be required. The Director may request additional protective devices as necessary.
- 10.0 Road Box: Road boxes are acceptable in locations where protective cover pipes are not suitable. All road boxes shall be secured and water tight and prevent easy access to the well. The well shall be fitted with a locking, water tight cap. The ground surface seal for the road box shall be competent such that vehicle traffic will not cause it to fail. The annular space seal shall extend upward to within one foot of the ground surface seal. One or two feet of permeable material may be emplaced between the ground surface seal and the annular space seal in order to allow for the drainage of runoff which may leak into the road box from the ground surface.
- 11.0 Well Development: Development of all monitoring wells shall be performed no earlier than 48 hours after completion and before the initial water quality samples are taken. The goal of well development is to produce water free of fine sand, coarser material, drill cuttings, and drilling fluids. The formation shall be allowed to stabilize for at least 24 hours before groundwater sampling.
- 12.0 Innovative Well Installation: Innovative wells, including but not limited to Microwells or Geoprobes, that are small-diameter and are non-destructive to the formation, and which are capable of providing samples representative of groundwater, need not meet the construction requirements set forth in Rules 4.0 through 11.0 of this Appendix.
- 13.0 Monitoring Well and Piezometer Abandonment:
- 13.1 General:

- (a): All monitoring wells and applicable piezometers as described in Rule 1.0 of this Appendix that are no longer used to gather information on geologic or groundwater properties shall be abandoned pursuant to the provisions of Rule 13.2 of this Appendix. Well abandonment shall take place within 60 days after its use has been terminated, unless a written exemption is received from the Director for continued use.
 - (b) Innovative wells: Innovative wells as described in Rule 12.0 of this Appendix shall be abandoned at the end of use in order to remove the conduit to groundwater. Abandonment of innovative wells shall consist of removal of the well and grouting of the borehole. Innovative wells are exempted from the abandonment procedures described in Rule 13.2 of this Appendix.
- 13.2 Abandonment Procedures: The well shall be inspected from the land surface through the entire depth of the well before it is sealed to ensure against the presence of any obstructions that will interfere with sealing operations.
- (a) Wells constructed with an impermeable annular seal shall be abandoned by cutting off the casing a minimum of 4 feet below land surface. The remaining casing shall be completely filled with a neat cement grout or bentonite-cement grout. The remaining hole volume shall be backfilled with natural material, with the following exception: where backfilling with natural material would result in a grout plug less than 4 feet long, the hole shall be filled to approximately one foot from the ground surface with the neat cement grout or bentonite-cement grout.
 - (b) Wells not known to be constructed with an impermeable annular seal shall be abandoned by completely removing the well casing and sealing with neat cement or bentonite-cement grout to approximately one foot from the ground surface. If the casing cannot be removed during the abandonment of a well, the casing shall be thoroughly ripped or perforated from top to bottom, except that perforations will not be required over intervals of the well that are sealed with cement. The screened portion of the well and the annular space between the casing and the drillhole wall shall be effectively and completely filled with cement or bentonite-cement grout applied under pressure.



CROSS-SECTION OF TYPICAL MONITORING WELL

After US EPA, 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Manual

**U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I**

**LOW STRESS (low flow) PURGING AND SAMPLING
PROCEDURE FOR THE COLLECTION OF
GROUND WATER SAMPLES
FROM MONITORING
WELLS**



**July 30, 1996
Revision 2**

**U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I**

**LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE
FOR THE COLLECTION OF GROUND WATER SAMPLES
FROM MONITORING WELLS**

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permeability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

Changes to this SOP should be proposed and discussed when the site Sampling and Analysis Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in field.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or

Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each record.

D. Flow measurement supplies (e.g., graduated cylinder and stop watch).

E. Interface probe, if needed.

F. Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.

G. Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.

H. Decontamination supplies (for example, non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.).

I. Logbook(s), and other forms (for example, well purging forms).

J. Sample Bottles.

K. Sample preservation supplies (as required by the analytical methods).

L. Sample tags or labels.

M. Well construction data, location map, field data from last sampling event.

N. Well keys.

O. Site specific Sample and Analysis Plan/Quality Assurance Project Plan.

P. PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and

total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.

2. Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.

3. Purge Well

3a. Initial Low Stress Sampling Event

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator

parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

- turbidity (10% for values greater than 1 NTU),
- DO (10%),
- specific conductance (3%),
- temperature (3%),
- pH (± 0.1 unit),
- ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values

measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter

size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

VII. FIELD LOGBOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

Well identification.

Well depth, and measurement technique.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and

detection method.

Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.

Well sampling sequence and time of each sample collection.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analysis.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

VIII. DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, and whatever field logbook information is needed to allow for a full evaluation of data useability.

Page _____ of _____

Location (Site/Facility Name) _____	Depth to _____ / _____ of screen
Well Number _____ Date _____	(below MP) top bottom
Field Personnel _____	Pump Intake at (ft. below MP) _____
Sampling Organization _____	Purging Device; (pump type) _____
Identify MP _____	

[illegible]

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. μ Siemens per cm (same as μ mhos/cm) at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

TOTAL VOLATILE ORGANIC COMPOUNDS JAR HEADSPACE SCREENING

The samples will be logged by the rig geologist, and standard headspace analysis will be performed using a flame ionization detector (FID) or photoionization detector (PID) field survey instrument as described below:

1. Half-fill one clean glass jar with the sample to be analyzed. Quickly cover each open jar top with one sheet of clean aluminum foil and subsequently apply the jar screw cap to tightly seal the jar. The jar must have a volume of 8 ounces or greater .
2. Shake the jar vigorously for 15 to 30 seconds and then allow the headspace to equilibrate for at least 10 minutes. When ambient temperatures are below 32 degrees F, the headspace equilibration should occur within a heated vehicle or building.
3. After headspace equilibration, remove the jar lid to expose the foil seal. Quickly puncture the foil seal with the FID probe tip, to a point approximately one-half of the available headspace depth. Exercise care when penetrating the foil seal in order to avoid uptake of water droplets or soil particulates.
4. Following the probe insertion through the foil seal, record the highest meter response as the total VOC headspace concentration. The maximum response should occur between 2 to 5 seconds after the insertion of the probe tip. Longer periods may create a vacuum inside the sample jar. Erratic meter response may occur at high VOC concentrations or conditions of elevated headspace water vapor in which case the headspace data should be considered suspect for that sample.

NOTE: The presence of methane can also interfere with the response of a FID instrument. FIDs have a very sensitive response to methane and which can mistakenly be considered as a high total VOC concentration. If methane is potentially present (e.g., landfill or wetland), a PID instrument may be substituted or used in unison with the FID. The PID instrument does not respond to methane, however high humidity can result in a poor VOC response.

APPENDIX C
TtNUS FIELD DOCUMENTATION FORMS

GRD SURFACE ELEVATION.

ELEVATION FROM

CHECKED BY:

[illegible]

OTHER OBSERVATIONS.

Tetra Tech NUS, Inc



BORING NO.:

PAGE. OF



TETRA TECH NUS, INC.

SAMPLE LOG SHEET - SOLID PHASE

 Site Name: _____
 Sample ID: _____

 Tetra Tech NUS Charge No. _____
 QC Information: _____ (if applicable)

 Sample Method: _____
 Depth Sampled: _____ feet
 Sample Date & Time: ____/____/____ hours Dup ____ hours
 Sampler(s): _____

 Data Recorded By: _____
 Signature

PID/OVA Monitor Reading: _____ ppm

TYPE OF SAMPLE: (Check all that apply)

_____ Soil	_____ Trip Blank*
_____ Sediment	_____ Rinsate Blank*
_____ Lagoon/Pond	_____ Field Duplicate collected
_____ Grab	_____ Other (Specify): _____

 Description: (Sand, Clay, Muck, Peat, Dry, Moist, Wet, Etc.)

 SAMPLE DATA/REMARKS: _____

ANALYSIS	BOTTLE LOT No.	NOTES/SKETCH:



TETRA TECH NUS, INC.

SAMPLE LOG SHEET - LIQUID PHASE

Site Name: _____
Sample ID: _____Tetra Tech NUS Charge No. _____
QC Information: _____ (if applicable)Sample Method/Device: _____
Depth Sampled: _____ feet Total Depth _____ feet (SW Only)
Sample Date & Time: ____/____/____ hours
Sampler(s): _____Recorded By: _____
Signature

TYPE OF SAMPLE: (Check all that apply)

<input type="checkbox"/> Groundwater	<input type="checkbox"/> Trip Blank*
<input type="checkbox"/> Surface Water	<input type="checkbox"/> Rinsate Blank*
<input type="checkbox"/> Residential Supply	<input type="checkbox"/> Field Duplicate Collected
<input type="checkbox"/> Grab	<input type="checkbox"/> Other (Specify): _____
<input type="checkbox"/> Composite	

*include sample source & lot No.

WELL PURGE DATA:

Micro Tip/OVA Monitor Reading: _____ ppm

Well Depth	feet	Purge Start	hrs
Inside Diameter	Inches	Purge Stop Time	hrs
Water Level	feet	Total Gallons Purged	
Well Volume	gal	Purge Method	
Color: _____ Turbidity: CLR/SL CLDY/CLDY/OPAQ			

Sampling/Purge Data:

Vol. #	Temp ? C	pH	Spec. Cond.	DO
0	_____	_____	_____	_____
1	_____	_____	_____	_____
3	_____	_____	_____	_____
4	_____	_____	_____	_____

ANALYSIS		BOTTLE LOT NO.		TRAFFIC REPORT NO.		COMMENTS
				ORGANIC	INORGANIC	

TETRA TECHNUS, INC.

WELL DEVELOPMENT DATA SHEET

Well No.: _____

PROJECT: _____

DATE: _____

PROJECT NO.: _____

WEATHER: _____

SAMPLE ID: _____

PERSONNEL: _____

Well Screen Depth: _____ / _____ ft. bgs

Pump Type/Material: _____

Total Purge Volume = _____ (gal)

H&S Monitoring Instrument Reading _____

Pump Intake Depth: _____

Data Recorded By: _____

[illegible]

FLUSH MOUNT MONITORING WELL CONSTRUCTION LOG

TETRA TECH NUS INC

PROJECT NAME	PROJECT NO
PROJECT LOCATION	WELL NO
CLIENT	BORING NO
CONTRACTOR	BORING LOCATION
LOGGED BY	DRILLER
CHECKED BY	DATE
	DATE
PAGE 1 OF 1	

FLUSH MOUNT PROTECTIVE CASING

GROUND ELEVATION

SAND DRAIN LAYER

LENGTH RISER PIPE BELOW GRD. SURF (Ft)

TYPE OF SURFACE SEAL

DIA SURFACE SEAL BGS (in)

DEPTH TO BOTTOM OF SURFACE SEAL (Ft)

I.D. OF PROTECTIVE CASING (in)

TYPE OF PROTECTIVE CASING

DEPTH BOTTOM OF PROTECTIVE CASING (Ft)

DEPTH BOTTOM OF DRAIN LAYER (Ft)

RISER PIPE (in) I.D. O.D.

TYPE OF RISER PIPE

TYPE OF BACKFILL AROUND RISER PIPE

DEPTH TOP OF SEAL (Ft)

TYPE OF SEAL

DEPTH BOTTOM OF SEAL (Ft)

DEPTH TOP OF PERVIOUS SECTION (Ft)

DIAMETER OF BOREHOLE (in)

TYPE OF PERVIOUS SECTION

TYPE OF OPENINGS

PERVIOUS SECTION (in) I.D. O.D.

TYPE OF FILTER PACK AROUND PERVIOUS SECTION

DEPTH BOTTOM OF PERVIOUS SECTION (Ft)

DEPTH BOTTOM OF FILTER PACK (Ft)

TYPE OF BACKFILL (GROUT) BELOW FILTER PACK

END OF BORING

GENERAL NOTE

1 Entry of 0.00 for Ground Elevation Indicates that Surveyed Ground Elevation is NOT Available

OVERBURDEN MONITORING WELL CONSTRUCTION LOG

TETRA TECH NUS, INC.

PROJECT NAME: _____		PROJECT NO: _____
PROJECT LOCATION: _____		WELL NO: _____
CLIENT: _____		BORING NO: _____
CONTRACTOR: _____	DRILLER: _____	BORING LOCATION: _____
LOGGED BY: _____	DATE: _____	
CHECKED BY: _____	DATE: _____	

PAGE: 1 OF 1

ELEVATION TOP OF PROTECTIVE CASING _____	LENGTH OF PROTECTIVE CASING ABOVE GROUND SURFACE (Ft.) _____
ELEVATION TOP OF RISER PIPE _____	LENGTH OF RISER PIPE ABOVE GROUND SURFACE (Ft.) _____
GROUND ELEVATION _____	TYPE OF SURFACE SEAL _____
SAND DRAIN LAYER _____	DIA. SURFACE SEAL BGS (In.) _____
	DEPTH TO BOTTOM OF SURFACE SEAL (Ft.) _____
	I.D. OF PROTECTIVE CASING (In.) _____
	TYPE OF PROTECTIVE CASING _____
	DEPTH BOTTOM OF PROTECTIVE CASING (Ft.) _____
	DEPTH BOTTOM OF DRAIN LAYER (Ft.) _____
	RISER PIPE (In.) I.D.: _____ O.D.: _____
	TYPE OF RISER PIPE _____
	TYPE OF BACKFILL AROUND RISER PIPE _____
	DEPTH TOP OF SEAL (Ft.) _____
	TYPE OF SEAL _____
	DEPTH BOTTOM OF SEAL (Ft.) _____
	DEPTH TOP OF PERVIOUS SECTION (Ft.) _____
	DIAMETER OF BOREHOLE (In.) _____
	TYPE OF PERVIOUS SECTION _____
	TYPE OF OPENINGS _____
	PERVIOUS SECTION (In.) I.D.: _____ O.D.: _____
	TYPE OF FILTER PACK AROUND PERVIOUS SECTION _____
	DEPTH BOTTOM OF PERVIOUS SECTION (Ft.) _____
	DEPTH BOTTOM OF FILTER PACK (Ft.) _____
	TYPE OF BACKFILL BELOW FILTER PACK _____
	END OF BORING (Ft.) _____

GENERAL NOTE:

1. Entry of 0.00 for Ground Elevation, Elev. Top of Riser Pipe & Elev. Top of Protective Casing Indicates that Surveyed Ground Elevation Not Available.



TETRA TECH NUS, INC.

PHOTOIONIZATION DETECTOR FIELD CALIBRATION LOG

Serial No.: _____

Model No.: _____

Decal No.: _____

Site Name/Location: _____

Tetra Tech NUS Charge No.: _____

CALIBRATION DATE	STANDARD GAS- ISOBUTYLENE	CALIBRATION READING Isobutylene Equiv. (ppm)	CALIBRATION CHECK Isobutylene Equiv. (ppm)	SIGNATURE	COMMENTS
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				
	Lot # _____ Conc. = _____ ppm				

SAMPLE COLLECTION SUMMARY RECORD

PROJECT NAME: _____ TETRA TECH NUS CHARGE NUMBER: _____

SAMPLING EVENT: _____ CASE NO.: _____ DAS NO.: _____

[illegible]



TETRA TECH NUS, INC.

YSI 6820 MULTIPARAMETER METER

Serial No.: _____ Model No.: _____ Decal No.: _____

Site Name: _____ Job No.: _____

Instrument is calibrated in accordance with Manufacturer's Instructions

DATE	Pre Calibration Readings	Post Calibration Readings	PM Check	Calibration STDs (lot #'s)	Signature	Remarks
Cond. mS/cm						
pH=4.0						
pH=7.0						
pH=10.0						
D.O. mg/l						
REDOX mV						
Turbidity 0 NTUs						
Turbidity 100 NTUs						
Temp °C						
Salinity 0/00						

DATE						
Cond mS/cm						
pH=4.0						
pH=7.0						
pH=10.0						
D O mg/l						
REDOX mV						
Turbidity 0 NTUs						
Turbidity 100 NTUs						
Temp °C						
Salinity 0/00						



HORIBA U-10 WATER QUALITY CHECKER

Serial No.: _____ Model No.: _____ Decal No.: _____

Site Name: _____ Job No.: _____ Buffer Lot No.: _____

Instrument is calibrated in accordance with Manufacturer's Instructions

[illegible]



TETRA TECH NUS, INC.

GROUNDWATER LEVEL MEASUREMENT

SITE INFORMATION

Site Name: _____ Municipality: _____
Project Number: _____ County: _____
Personnel: _____ State: _____
Date: _____ Street or Map Location: _____
(If Off-Site): _____

WEATHER CONDITIONS AND EQUIPMENT

Temperature Range: _____ Equipment No.: _____
Precipitation: _____ Equipment Number: _____
Barometric Pressure: _____ Latest Calibration Date: _____
Tidally-Influenced ☐ Yes ☐ No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

TtNUS Form 0010

* measured made to 0.00 feet



TETRA TECH NUS, INC.

WELL INSPECTION AND GROUNDWATER LEVEL
MEASUREMENT SHEET

WELL NUMBER: _____ PROJECT NAME: _____

DATE/TIME: _____ PROJECT MANAGER: _____

INSPECTED BY: _____

VENT WELL

MONITORING INSTRUMENT READING: _____

LEL/O2 READING: _____

WELL INSPECTION/GROUNDWATER LEVEL MEASUREMENT

WELL DEPTH (FEET FROM TOP OF PVC) _____

WATER LEVEL DEPTH (FEET FROM TOP OF PVC) _____

WELL STICK-UP _____

CASING STICK-UP (FEET) _____

WELL DIAMETER (INCHES) _____

WELL CONSTRUCTION (PVC, STEEL, ETC.) _____

LOCKED UPON ARRIVAL? YES NO

LOCKED REPLACED? YES NO

OBSTRUCTIONS? YES NO

WELL RELABELED? YES NO

SLUG TEST CONDUCTED? YES NO (If YES, refer to "Hydraulic
Conductivity Testing Data
Sheet")

GENERAL CONDITION/COMMENTS: _____



TETRA TECH NUS, INC.

JAR HEADSPACE ANALYSIS LOG

SITE NAME: _____
SITE LOCATION: _____
PROJECT No./CTO No.: _____
SAMPLE LOCATION: _____
INSTRUMENT: _____
SERIAL No.: _____
MODEL No.: _____
SAMPLE PREP METHOD¹ _____
HEADSPACE ANALYST: _____
DATE: _____

SAMPLE TYPE ² /NUMBER	SAMPLE DEPTH (FEET)	READING (ppm)	COMMENTS

TtNUS Form 0008

- 1) (a) ambient temp
(h) heated (air)
(w) hot water bath

- 2) Type of Sample
SB Soil Boring
SD Sediment Sample

GW Groundwater Sample
TP Test Pit Sample

SS Soil Sample



SAMPLE LOG SHEET - "LOW FLOW" GROUNDWATER

Tetra Tech NUS Charge No. _____
QC: _____ (If applicable)

H&S Survey Meter _____ PPM Field Instrument Group A/B/C/D
Pre-pump insertion WL _____ ft Post - pump insertion WL _____ ft

Analysis Bottle Lot # Analysis Bottle Lot # Analysis Bottle Lot #

[illegible]

TtNUS Form 0009

1. Pump dial setting (for example hertz, cycle/min, etc.)
2. Siemens per cm (same as umhos/cm) at 25 °C
3. Oxidation reduction potential (stand in for Eh)



Tetra Tech NUS Charge No. _____
QC: _____ (If applicable)

Site Name: _____
Sample ID: _____

[illegible]

TtNUS Form 0009

1. Pump dial setting (for example, hertz, cycle/min, etc.)
2. Siemens per cm (same as umhos/cm) at 25 °C.
3. Oxidation reduction potential (stand in for Eh).



TETRA TECH NUS, INC.

FIELD MODIFICATION RECORD

Site Name: _____ Location: _____

Project Number: _____ Task Assignment: _____

To: _____ Location: _____ Date: _____

Description: _____

Reason for Change: _____

Recommended Action: _____

Field Operations Leader (Signature): _____ Date: _____

Disposition/Action: _____

Project Manager (Signature): _____ Date: _____

Distribution: Program Manager: _____ Others as Required: _____

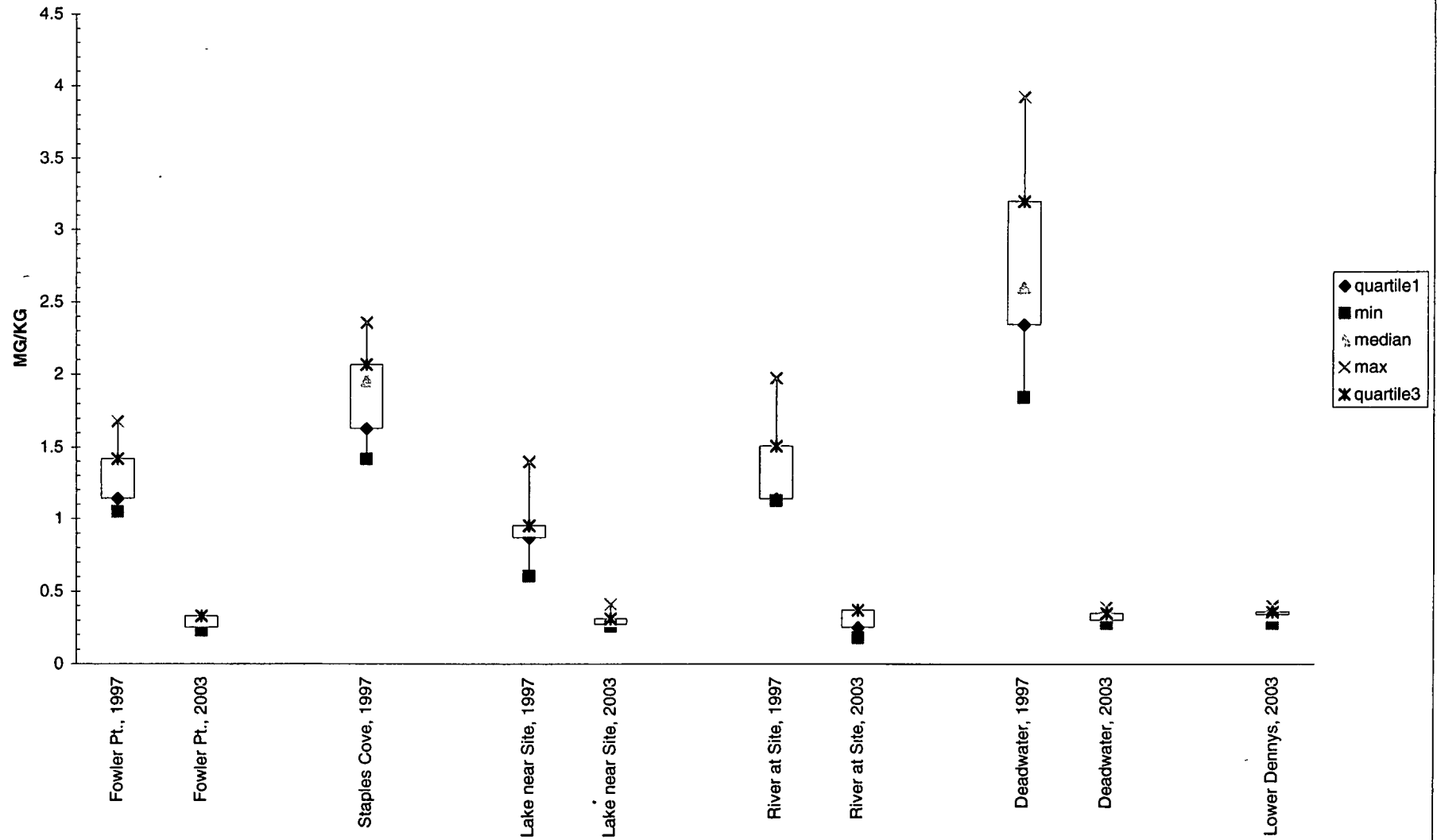
Project Manager: _____

Quality Assurance Officer: _____

Field Operations Leader: _____

Project File: _____

Mercury in Smallmouth Bass (Fillet)



APPENDIX D

FINAL REPORT AND RISK ASSESSMENT FOR WORKER EXPOSURE AT THE SWOS SITE

**U.S. NAVY ENGINEERING FIELD ACTIVITY NORTHEAST
REMEDIAL ACTION CONTRACT (RAC)
CONTRACT NO. N62472-99-D-0032
TASK ORDER NO. 0093**

**FINAL REPORT AND RISK ASSESSMENT
FOR WORKER EXPOSURE
AT THE SWOS SITE
NAVAL STATION NEWPORT
PORTSMOUTH, RHODE ISLAND**

September 5, 2003

Prepared by

Foster Wheeler Environmental Corporation
133 Federal Street
Boston, Massachusetts 02110



Revision
0

Date
9/5/03

Prepared by
J. McIntosh

Approved by
S. Leach, P.E.

Pages Affected
All

TABLE OF CONTENTS

EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 General Information.....	1-1
1.2 NAVSTA	1-1
1.2.1 Surface Warfare Officer's School.....	1-1
1.3 Previous Testpitting	1-3
1.4 Sampling Plan Development and Deviations from the Plan	1-3
1.4.1 Deviations from the Plan: Sampling Locations and Collection Methodology ..	1-3
2.0 QUALITY ASSURANCE/QUALITY CONTROL SOIL DATA REVIEW	2-1
2.1 Objectives	2-2
3.0 RISK ASSESSMENT	3-1
3.1 Conceptual Site Model.....	3-1
3.2 Chemicals of Potential Concern.....	3-1
3.3 Exposure Point Concentrations.....	3-1
3.4 Exposure Assessment.....	3-7
3.5 Toxicity Assessment.....	3-7
3.6 Risk Characterization.....	3-10
3.7 Uncertainty Analysis.....	3-17
4.0 REFERENCES	4-1

LIST OF FIGURES

Figure 1-1	Coasters Harbor Island Site Location Map	1-2
Figure 1-2	Previous Testpitting, Proposed Electrical Line Installation, and July 2003 Sample Locations at the SWOS Site.....	1-5

LIST OF TABLES

Table 1-1	Testpit Subsurface Soil Analytical Results and Screen Against RIDEM I/C Criteria.....	1-6
Table 2-1	Samples Collected and Analyses Performed	2-1
Table 3-1	Selection of Exposure Pathways.....	3-2
Table 3-2	Occurrence, Distribution, and Selection of Chemicals of Potential Concern	3-3
Table 3-3	Exposure Point Concentration Summary	3-6
Table 3-4	Values Used for Daily Intake Calculations - Reasonable Maximum Exposure	3-8
Table 3-5	Non-Cancer Toxicity Data – Oral/Dermal.....	3-11
Table 3-6	Non-Cancer Toxicity Data – Inhalation.....	3-12
Table 3-7	Cancer Toxicity Data – Oral/Dermal.....	3-13
Table 3-8	Cancer Toxicity Data – Inhalation.....	3-14
Table 3-9	Calculation of Chemical Cancer Risks and Non-Cancer Hazards	3-15
Table 3-10	Summary of Receptor Risks and Hazards for COPCs	3-19

LIST OF APPENDICES

Appendix A	Data Quality Review Details
Appendix B	Intake Calculations for the Construction Worker Soil Exposures

EXECUTIVE SUMMARY

Foster Wheeler Environmental Corporation (Foster Wheeler) has prepared this Final Report and Risk Assessment for Construction Worker Exposure at the future Surface Warfare Officer's School (SWOS) site, which is located on Coaster's Harbor Island at the Naval Station Newport (NAVSTA), Portsmouth, Rhode Island. Construction of the SWOS and associated activities are being conducted by Military Construction (MILCON). During excavation to enable utility line installation for the SWOS, oily soils were discovered. In May 2003, Foster Wheeler conducted testpitting and collected samples to assess the concentrations of total petroleum hydrocarbons (TPH) and lead at depth (3-8-ft below ground surface [bgs]). Ten samples were collected and TPH and lead concentrations at 3 testpit locations at depth ranging from 4-8-ft bgs exceeded the Rhode Island Department of Environmental Management Industrial/Commercial Criteria. To enable completion of the utility line installation for the SWOS, in July 2003, Foster Wheeler developed a Sampling Plan for the SWOS site designed to collect representative samples of the soil that the MILCON construction workers would be exposed to during utility line installation and asphalt parking lot construction. The maximum depth associated with these construction tasks would be 3-ft bgs. In July 2003, Foster Wheeler collected a total of 10 surface and 10 subsurface soil samples. All samples were analyzed for total analyte list (TAL) metals and target compound list (TCL) constituents (PCBs, VOCs, pesticides, and SVOCs). Foster Wheeler reviewed the quality of the analytical data from the July 2003 sampling event and conducted a risk assessment to determine construction worker exposure risks during utility line installation and asphalt parking lot construction, which are included herein.

The analytical data for the project was found to be acceptable. Some data qualifications were made as noted herein in the organic and inorganic fractions due to field duplicates, MS/MSD, surrogate recovery, calibration verification, and PCB/pesticide target compound identification. A number of results for 2,4-dinitrophenol were rejected due to poor recovery in the laboratory control samples.

The construction worker evaluated in the risk assessment was calculated to have an excess lifetime cancer risk (ELCR) of 2.2×10^{-7} , which is below the United States Environmental Protection Agency acceptable risk range. This risk is lower than the most stringent endpoint of the USEPA's acceptable target risk range (i.e., 10^{-6} to 10^{-4} ELCR). The construction worker evaluated in this risk assessment was calculated to have a hazard index (HI) of 0.033, which is well below the USEPA's Threshold HI of 1.0.

1.0 INTRODUCTION

1.1 General Information

Foster Wheeler Environmental Corporation (Foster Wheeler) has prepared this Final Report and Risk Assessment for Worker Exposure for individuals constructing the Surface Warfare Officer's School (SWOS) at the Naval Station Newport, Portsmouth, Rhode Island (NAVSTA). Development of this report and associated activities were conducted under the U.S. Navy Engineering Field Activities Northeast (EFANE) Remedial Action Contract (RAC) N62472-99-D-0032, Contract Task Order 93 (CTO 93). The objective of this report is to identify the locations where soil samples were collected at the SWOS site on July 28-29, 2003 to support the risk assessment attached herein, include and discuss the quality of the analytical data from the July 2003 sampling event, and describe the results of the risk assessment for future construction worker exposure at the SWOS site.

1.2 NAVSTA

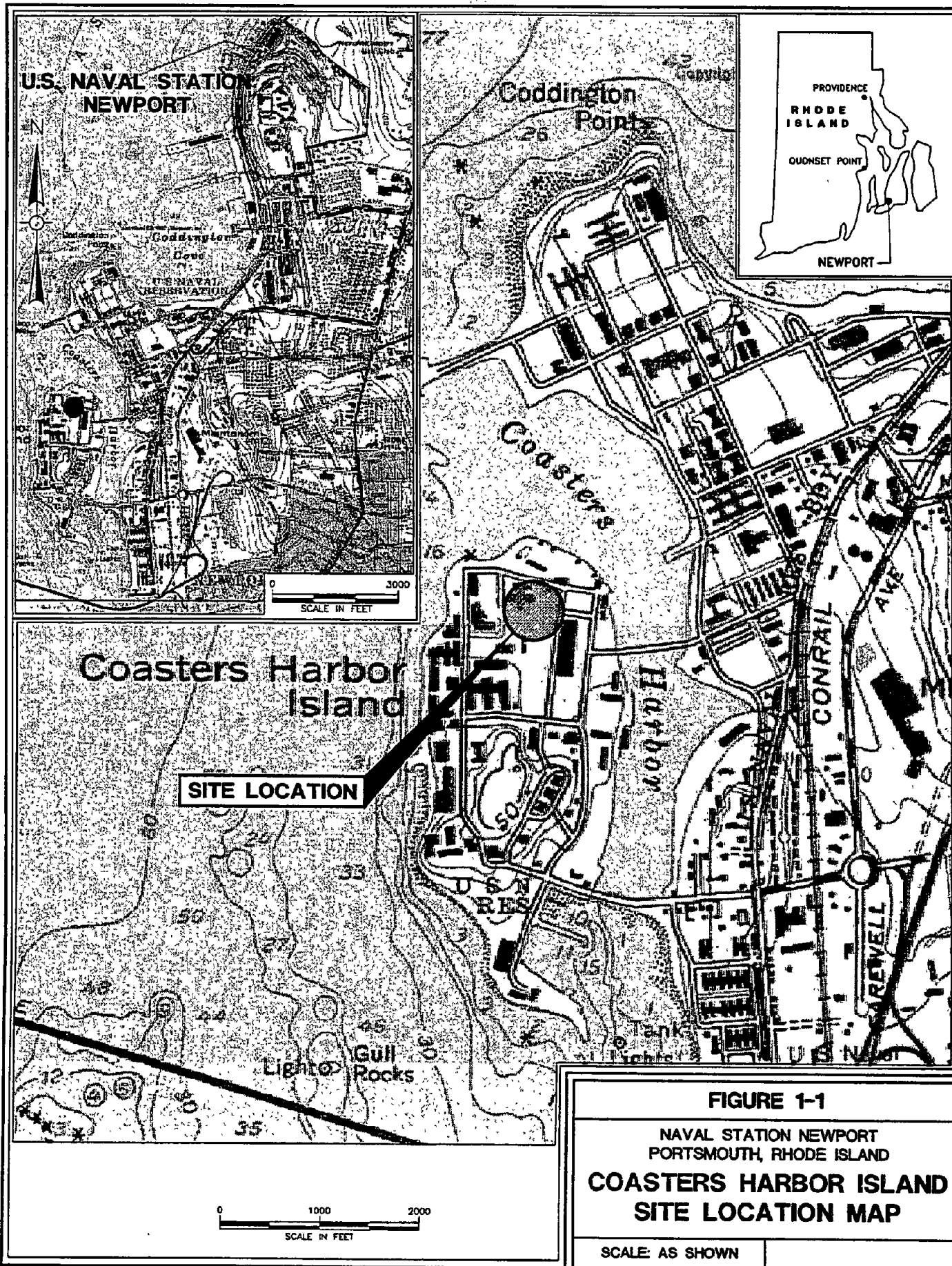
NAVSTA Newport is located approximately 60 miles southwest of Boston, Massachusetts and 25 miles south of Providence, Rhode Island (see Figure 1-1). It occupies approximately 1,063 acres, with portions of the facility located in the City of Newport and Towns of Middletown and Portsmouth, Rhode Island. The facility layout is long and narrow, following the western shoreline of Aquidneck Island for nearly 6 miles facing the east passage of Narragansett Bay.

The NAVSTA Newport facility has been in use by the Navy since the Civil War. During both World Wars I and II, military activities at the facility increased significantly and the base provided housing for many service people. In subsequent years, use of the on-site facilities were slowly phased out until Newport became headquarters of the Commander-Cruiser Destroyer Force Atlantic in 1962. In April 1973, the Shore Establishment Realignment (SER) Program resulted in the reorganization of naval forces, and activity again declined.

The entire NAVSTA Newport facility was listed on the U.S. Environmental Protection Agency (USEPA) National Priorities List (NPL) of abandoned or uncontrolled hazardous waste sites in November 1989. A Federal Facilities Interagency Agreement (FFA) for NAVSTA Newport was signed by the Navy, the State of Rhode Island, and the USEPA on March 23, 1992. The FFA outlines response action requirements under the Department of Defense Installation Restoration Program (IRP) at NAVSTA Newport.

1.2.1 Surface Warfare Officer's School

A Military Construction (MILCON) project is underway at Coaster's Harbor Island, NAVSTA, which is shown on Figure 1-1. MILCON is erecting a Surface Warfare Officer's School (SWOS) at the northern end of Coaster's Harbor Island. In the process of performing soil excavation to install subsurface utility lines, oily soils were discovered in areas adjacent to Taylor Drive. The field sampling identified in Sections 1.3 and 1.4 of this report were conducted. The results of the sampling discussed in Section 1.4 were input into a risk assessment to assess the exposure risks to MILCON project construction workers so that they may continue with the installation of electrical utility lines and parking lot construction. The risk assessment is also included herein and will serve as an addendum to the construction contractor's Site Specific Health and Safety Plan.



CADDFILE: 0931_A003.DWG

1.3 Previous Testpitting

On behalf of the Navy, on May 19, 2003, Foster Wheeler conducted testpitting in the area where the oily soils were observed. A total of five testpits were excavated. Each testpit was approximately 8 feet (ft) long by 6-ft wide. Individual testpits ranged between 4 and 8-ft in depth. Figure 1-2 shows the approximate locations of the testpits. Two samples were collected from each testpit at varying depths. Quality control/quality assurance (QA/QC) samples were also collected during the sampling effort. The samples were sent to AMRO Analytical Laboratory located in Merrimack, New Hampshire for lead and total petroleum hydrocarbon (TPH) analyses. Lead was analyzed using USEPA Method 6010B and TPH was analyzed using USEPA Method 8015B. Foster Wheeler received the analytical results on May 23, 2003.

Table 1-1 identifies the testpit sample analytical results. Table 1-1 contains a summary of the analytical results, a brief description of field conditions identified during sampling, and a qualifier describing the sample identification numbers. On May 28, 2003, the analytical results were screened against Rhode Island Department of Environmental Management (RIDEM) Industrial/Commercial Direct Exposure Criteria. As shown in Table 1-1, one sample (ID# NS-TP5-B-8) contained a lead concentration of 3,400 ppm, which exceeds the RIDEM I/C Criteria of 500 ppm. Three samples contained TPH concentrations that exceeded the RIDEM I/C Criteria of 2,500 ppm. These samples were NS-TP4-B-4, NS-TP4-B-5, and NS-TP2-B-4. The respective concentrations in these samples were 5,200 ppm, 3,300 ppm, and 12,000 ppm.

1.4 Sampling Plan Development and Deviations from the Plan

On July 21, 2003, a Final Sampling Plan to Support Construction Worker Exposure was submitted to the Navy by Foster Wheeler. The objective of the sampling effort was to collect representative data from the SWOS site to enable the development of a risk assessment for constructor worker exposure so that utility line installation and parking lot construction may be completed. Future utility installation will include electrical lines that will be installed at a maximum depth of 3 feet (ft) below ground surface (bgs). The length of the electrical lines to be installed is approximately 1,000 lineal feet (lf). The approximate locations of the subsurface electrical lines are shown on Figure 1-2. After electrical line installation, an asphalt parking lot will be constructed. Installation of the SWOS parking lot will involve regrading and reworking of the existing soil to an approximate depth of 1.5-ft bgs.

In accordance with the Final Sampling Plan (July 2003), a total of 10 surface soil and 10 subsurface soil samples were collected from ten sampling locations. One surface soil and one subsurface soil sample was collected from each location. Surface soil was taken from the 0-1.5-ft bgs interval. Subsurface soil samples were collected from the 1.5-3.0-ft bgs interval. If stained or odorous soil existed, it was preferentially collected for analyses. Field personnel used a Trimble Pro XRS hand-held Global Positioning System (GPS) field instrument to record the location of each of the 10 sample locations shown on Figure 1-2. Please refer to the Final Sampling Plan (July 2003) for information regarding the analytical methodologies and risk assessment parameters and assumptions.

1.4.1 Deviations from the Plan: Sampling Locations and Collection Methodology

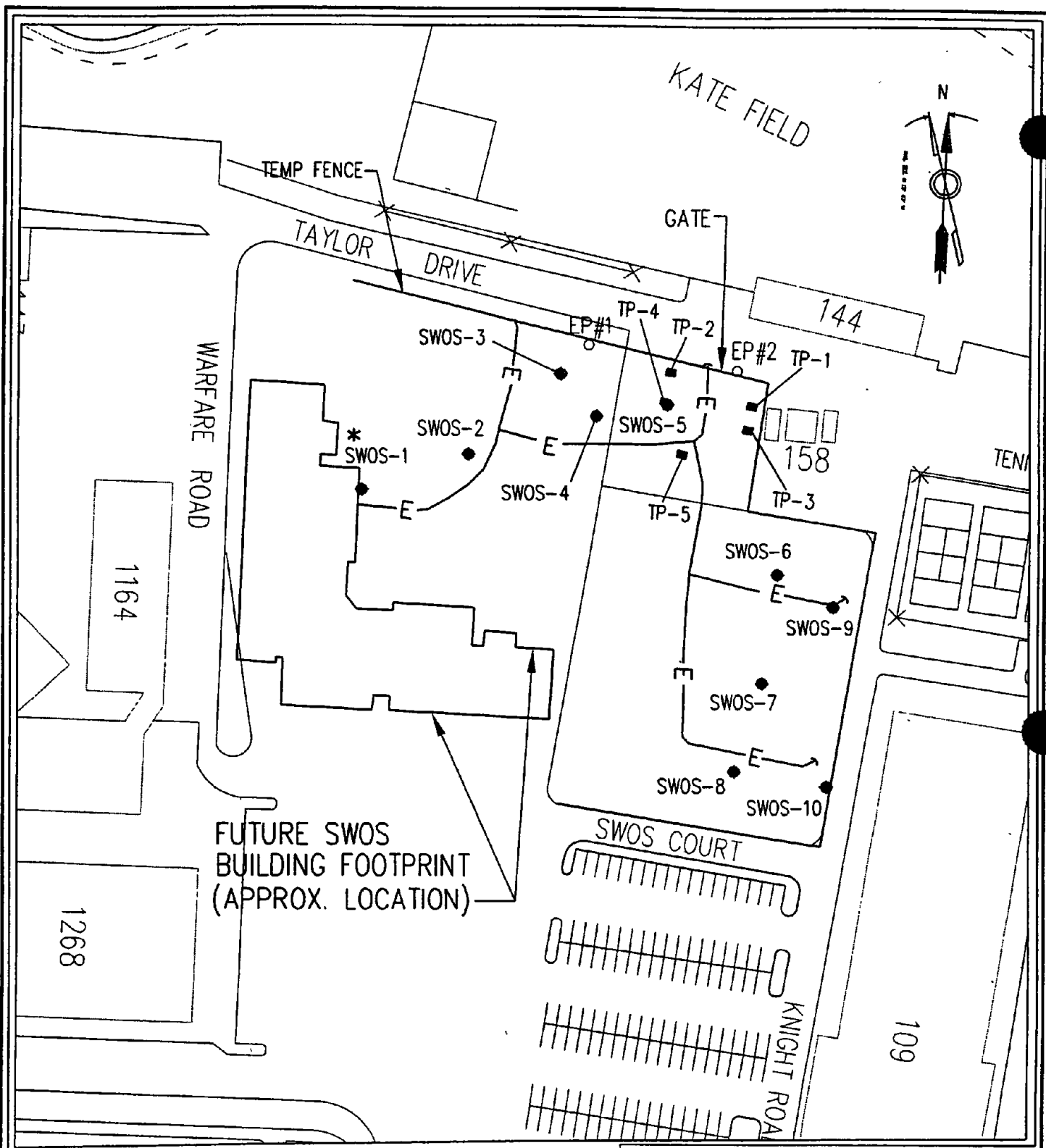
Due to existing utility line orientation and placement, construction laydown area placement, and impenetrable soil at certain locations, surface and subsurface soil sampling locations deviated slightly from those locations proposed in the Final Sampling Plan (July 2003). The actual sample locations were surveyed using the GPS unit and the approximate locations are shown on Figure 1-2.

The Final Sampling Plan (July 2003) indicated that field personnel would use a dedicated hand-held shovel to manually dig soil until a depth of 1.5-ft has been reached. Upon removal of the soil, personnel will place the excavated soil into disposable containers and would collect the VOC sample directly from the material within the disposable container. After collection of the VOC sample, the soil in the disposable container will be homogenized so that a composite sample may be collected for TAL metals, PCBs, SVOCs, and pesticides. Therefore, with the exception of the VOC samples, the plan suggested that the soil samples sent for off-site analysis would be composite sample representative of the 0-1.5-ft bgs interval. The same technique was planned for soil sample collection from the 1.5-3.0-ft interval.

The above technique was used for collection of the following four samples, sample depths are shown in parentheses:

- SWOS-8(0-1.5)
- SWOS-9(0-1.5)
- SWOS-10(0-1.5)
- SWOS-10(1.5-3)

Because the soil at the other locations was compacted as a result of MILCON-related construction activities, the soil was impenetrable using manual excavation at all other proposed sampling locations. To remedy this, on July 29, 2003, a Bobcat equipped with an auger was mobilized to the site and was used to advance each borehole to the depth of interest. A shovel was then used to collect each sample from the specified depths in accordance with the Final Sampling Plan. During sample collection, the PCB, TAL metals, pesticides, and SVOCs analyses were incorrectly noted as grab samples on the sample labels and chain-of-custody sheets when they were in fact composite samples. On July 30, 2003, the laboratory was notified of this error and noted this on the chain-of-custody for these samples.



KEY:

- E— LOCATION OF ELECTRIC LINE TO BE INSTALLED
- ELECTRIC POLE
- TEST PIT LOCATION
- SAMPLE COLLECTION LOCATION
- * APPROXIMATE LOCATION

NOTE:
ELECTRIC LINE LOCATION IS APPROXIMATE.

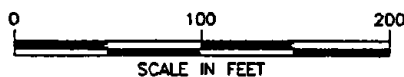


FIGURE 1-2

NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND
**PREVIOUS TESTPITTING, PROPOSED
ELECTRICAL LINE INSTALLATION,
AND JULY 2003 SAMPLE LOCATIONS
AT THE SWOS SITE**

SCALE: AS SHOWN

Table 1-1
Testpit Subsurface Soil Analytical Results and Screen Against RIDEM I/C Criteria

CTO 93 SWOS Parking Lot
Results of Testpitting Conducted 05/19/03

SAMP_ID	PARAMETER	Care or Non-Care?	RESULT (mg/kg)	RIDEM - Industrial (ppm)	Exceed Industrial? (Y/N)	DATE ANALYZED	METHOD	LAB ID	CAS NO	NOTES
NS-EQPT-RIN	Lead	nc	ND	500	N	5/21/2003	SW6010B	0305152-01	7439-92-1	
	TPH		0.093	2500	N	5/21/2003	SW8015B			
NS-TP5-B-6	Lead	nc	500	500	N	5/21/2003	SW6010B	0305152-02	7439-92-1	Sample collected from Testpit 5, from the excavation base, 6-ft from soil surface.
	TPH		100	2500	N	5/22/2003	SW8015B			
NS-TP5-B-8	Lead	nc	3,400	500	N	5/21/2003	SW6010B	0305152-03	7439-92-1	Sample collected from Testpit 5, from the excavation base, 8-ft from soil surface.
	TPH		100	2500	N	5/22/2003	SW8015B			
NS-TP4-B-4	Lead	nc	110	500	N	5/21/2003	SW6010B	0305152-04	7439-92-1	Sample collected from Testpit 4, from the excavation base, 4-ft from soil surface.
	TPH		5,200	2500	N	5/22/2003	SW8015B			
NS-TP4-B-5	Lead	nc	85	500	N	5/21/2003	SW6010B	0305152-05	7439-92-1	Sample collected from Testpit 4, from the excavation base, 5-ft from soil surface.
	TPH		3300	2500	N	5/22/2003	SW8015B			
NS-TP2-B-3	Lead	nc	200	500	N	5/21/2003	SW6010B	0305152-06	7439-92-1	Sample collected from Testpit 2, from the excavation base, 3-ft from soil surface.
	TPH		1800	2500	N	5/22/2003	SW8015B			
NS-TP2-B-4	Lead	nc	240	500	N	5/21/2003	SW6010B	0305152-07	7439-92-1	Sample collected from Testpit 2, from the excavation base, 4-ft from soil surface.
	TPH		12000	2500	N	5/22/2003	SW8015B			
NS-TP1-B-4	Lead	nc	51	500	N	5/21/2003	SW6010B	0305152-08	7439-92-1	Sample collected from Testpit 1, from the excavation base, 4-ft from soil surface.
	TPH		38	2500	N	5/22/2003	SW8015B			
NS-TP1-B-4-FD	Lead	nc	45	500	N	5/21/2003	SW6010B	0305152-09	7439-92-1	Sample collected from Testpit 1, from the excavation base, 4-ft from soil surface (field duplicate).
	TPH		38	2500	N	5/22/2003	SW8015B			
NS-TP1-B-6-5	Lead	nc	170	500	N	5/22/2003	SW6010B	0305152-10	7439-92-1	Sample collected from Testpit 1, from the excavation base, 6-5-ft from soil surface.
	TPH		63	2500	N	5/22/2003	SW8015B			
NS-TP3-B-4	Lead	nc	130	500	N	5/22/2003	SW6010B	0305152-11	7439-92-1	Sample collected from Testpit 3, from the excavation base, 4-ft from soil surface.
	TPH		75	2500	N	5/22/2003	SW8015B			
NS-TP3-B-6	Lead	nc	110	500	N	5/22/2003	SW6010B	0305152-12	7439-92-1	Sample collected from Testpit 3, from the excavation base, 6-ft from soil surface.
	TPH		67	2500	N	5/22/2003	SW8015B			

2.0 QUALITY ASSURANCE/QUALITY CONTROL SOIL DATA REVIEW

A quality assurance/quality control (QA/QC) data review was performed on the results of soil samples collected at the SWOS site on July 28-29, 2003. Mitkem Corporation of Warwick, RI analyzed the samples for selected Volatile Organics (VOCs - USEPA Method 8260B), selected Semivolatile Organics (SVOCs - USEPA Method 8270C), Pesticides (USEPA Method 8081A), Polychlorinated Biphenyls (PCBs - USEPA Method 8082), and Total TAL Metals (USEPA Methods 6010B/7000). Overall, data for this project were found to be acceptable. Some data qualifications were made as noted in the organic or inorganic fractions due to field duplicates, MS/MSD, surrogate recovery, calibration verification, and PCB/Pesticide target compound identification. A number of results for 2,4-dinitrophenol were rejected due to poor recovery in the laboratory control samples. Based on this review, the qualified data are considered acceptable for project objectives.

Table 2-1 provides a list of sample numbers, dates collected, laboratory IDs, and the analyses performed.

Table 2-1
Samples Collected and Analyses Performed

Sample Number	SDG	Date Collected	LAB ID	VOC	SVOC	PAHs	PPCB	TAL Metals
SWOS-Eqpt-Rinst	B1229	7/28/03	B1229-01	x	x	x	x	x
SWOS-9(0-1.5)	B1229	7/28/03	B1229-02	x	x	x	x	x
SWOS-10(0-1.5)	B1229	7/28/03	B1229-03	x	x	x	x	x
SWOS-10(1.5-3)	B1229	7/28/03	B1229-04	x	x	x	x	x
SWOS-8(0-1.5)	B1229	7/28/03	B1229-05	x	x	x	x	x
SWOS-5(0-1.5)	B1235	7/29/03	B1235-01	x	x	x	x	x
SWOS-5(1.5-3)	B1235	7/29/03	B1235-02	x	x	x	x	x
SWOS-4(0-1.5)	B1235	7/29/03	B1235-03	x	x	x	x	x
SWOS-4(1.5-3)	B1235	7/29/03	B1235-04	x	x	x	x	x
SWOS-3(0-1.5)	B1235	7/29/03	B1235-05	x	x	x	x	x
SWOS-3(1.5-3)	B1235	7/29/03	B1235-06	x	x	x	x	x
SWOS-9(1.5-3)	B1235	7/29/03	B1235-07	x	x	x	x	x
SWOS-8(1.5-3)	B1235	7/29/03	B1235-08	x	x	x	x	x
SWOS-7(0-1.5)	B1235	7/29/03	B1235-09	x	x	x	x	x
SWOS-7(1.5-3)	B1235	7/29/03	B1235-010	x	x	x	x	x
SWOS-6(0-1.5)	B1235	7/29/03	B1235-011	x	x	x	x	x
SWOS-6(1.5-3)	B1235	7/29/03	B1235-012	x	x	x	x	x
SWOS-2(0-1.5)	B1235	7/29/03	B1235-013	x	x	x	x	x
SWOS-2(1.5-3)	B1235	7/29/03	B1235-014	x	x	x	x	x
SWOS-1(0-1.5)	B1235	7/29/03	B1235-015	x	x	x	x	x
SWOS-1(1.5-3)	B1235	7/29/03	B1235-016	x	x	x	x	x
FIELD DUP	B1235	7/29/03	B1235-017	x	x	x	x	x

2.1 Objectives

The sample results and quality control data summarized on the laboratory reporting forms were reviewed for the following QA/QC criteria:

- Holding times
- Laboratory, preparation, and trip blanks
- Field and laboratory duplicate precision
- MS/MSD recoveries and relative percent differences (RPDs)
- Surrogate standard recoveries
- Laboratory control samples
- Internal standard areas
- PCB and pesticide target compound identification

The review performed on these QA/QC criteria was limited in scope and focused on laboratory summary sheets. A more comprehensive examination of the raw data (which, for example, would be included in an USEPA Tier III data validation) was not included within the Scope of Work. For details of the analytical data review, refer to Appendix A.

3.0 RISK ASSESSMENT

3.1 Conceptual Site Model

The Conceptual Site Model (CSM) was developed to focus on a planned future construction worker at the site who would come into contact with surface and subsurface soil (down to a depth of three feet) along the planned route of the subsurface utilities in the parking lot area. Incidental ingestion, dermal absorption, and inhalation of particulates generated by the excavation/construction activity are the exposure routes associated to be evaluated relative to the soil in these areas (see Table 3-1).

3.2 Chemicals of Potential Concern

The risk assessment was performed using the surface soil and subsurface soil data collected as part of this task (see Section 1.4). Chemicals of Potential Concern (COPCs) were identified using the screening process described in Risk Assessment Guidance for Superfund (RAGS) Part A (USEPA, 1989). This COPC identification process includes the following steps.

- The analytical data for all detected chemicals were compiled and the minimum and maximum detected concentrations were tabulated in RAGS Part D (USEPA, 2001c) format.
- The frequency of detection for each detected chemical were calculated and chemicals that were detected at a very low frequency were eliminated from the COPC list. For this sampling effort, because a total of 20 samples were collected, a "very low frequency" was defined as non-detect or only 1 detected sample out of 20 in accordance with RAGS Part A (USEPA, 1989).
- The maximum detected concentration for each detected chemical was compared to a chemical-specific toxicity screening criteria. Any chemical whose maximum concentration was less than the toxicity screening criteria was eliminated from the COPC list. The toxicity screening criteria used was the Region 9 Preliminary Remediation Goals (USEPA, 2002) for residential soil based on a target carcinogenic risk of 1×10^{-6} and a target non-carcinogenic hazard index of 0.1.
- Essential human nutrients (calcium, iron, magnesium, potassium, and sodium), as defined in RAGS Part A (USEPA, 1989) Section 5.9.4, were eliminated from the COPC list.
- Chemicals that were detected at levels consistent with background were eliminated from the COPC list. The background soil concentrations were taken from the Kay Field/Old Fire Fighting Training Area (OFFTA) Site (Tetra Tech NUS, 2000).

The remaining chemicals, identified as COPCs, were carried through the quantitative portion of the risk assessment. Table 3-2 summarizes the COPC screening process and results.

3.3 Exposure Point Concentrations

Exposure point concentration (EPCs) were developed for each identified COPC. The 95% upper confidence limit (UCL) on the mean was calculated for each COPC using the USEPA software, ProUCL (Version 2.1) (USEPA, 2001a). ProUCL uses a statistical test to determine if the data distribution for a COPC has a normal, lognormal, or nonparametric distribution. Based on this determination, ProUCL calculates the most technically appropriate UCL value. The minimum of the 95% UCL or the maximum detected value was taken as the EPC. Table 3-3 summarizes the EPC calculations.

TABLE 3-1
SELECTION OF EXPOSURE PATHWAYS
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Soil	Soil	Soil	Construction Worker	Adult	Incidental Ingestion	Quantitative	Associated with planned development activity.
						Dermal Absorption	Quantitative	
						Inhalation of Particulates	Quantitative	

TABLE 3-2
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Soil	72548	4,4-DDD	0 01	0 01	mg/kg	SWOS-9(1 5-3)	1 / 20	0 0035 - 0 0045	0 01	N/A	2 4 (ca)	N/A	N/A	N	BSL, IFD
	72559	4,4-DDE	0 0044 (J)	0 034	mg/kg	SWOS-10(1 5-3)	7 / 20	0 0035 - 0 0045	0 034	N/A	1 7 (ca)	N/A	N/A	N	BSL
	50293	4,4-DDT	0 0041	0.045	mg/kg	SWOS-10(1 5-3)	6 / 20	0 0035 - 0 0045	0 045	N/A	1 7 (ca)	N/A	N/A	N	BSL
	309002	Aldrin	0 0026 (J)	0 0026 (J)	mg/kg	SWOS-4(1.5-3)	1 / 20	0 0018 - 0 0023	0 0026	N/A	0 029 (ca)	N/A	N/A	N	BSL, IFD
	5103719	alpha-Chlordane	0 0022 (J)	0 0022 (J)	mg/kg	SWOS-9(1 5-3)	1 / 20	0 0018 - 0 0023	0 0022	N/A	1 6 (ca)	N/A	N/A	N	BSL, IFD
	5103742	gamma-Chlordane	0 0021 (J)	0 003	mg/kg	SWOS-4(1 5-3)	2 / 20	0 0018 - 0 0023	0 003	N/A	1 6 (ca)	N/A	N/A	N	BSL
	87616	1,2,3-Trichlorobenzene	0 004	0 004	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0 004	N/A	N/A	N/A	N/A	N	IFD
	120821	1,2,4-Trichlorobenzene	0 003	0 003	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0 003	N/A	65 (nc)	N/A	N/A	N	BSL, IFD
	95636	1,2,4-Trimethylbenzene	0.0008	0 002	mg/kg	SWOS-4(1.5-3)	3 / 20	0 0002 - 0 0008	0 002	N/A	5 2 (nc)	N/A	N/A	N	BSL
	95501	1,2-Dichlorobenzene	0 001	0 001	mg/kg	SWOS-8(1 5-3)	1 / 20	0 0002 - 0 0008	0 001	N/A	370 (sat)	N/A	N/A	N	BSL, IFD
	108878	1,3,5-Trimethylbenzene	0 0008	0 0009	mg/kg	SWOS-4(1.5-3)	2 / 20	0 0002 - 0 0008	0 0009	N/A	2 1 (nc)	N/A	N/A	N	BSL
	541731	1,3-Dichlorobenzene	0 001	0 001	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0 001	N/A	1 6 (nc)	N/A	N/A	N	BSL, IFD
	106467	1,4-Dichlorobenzene	0 0007	0 002	mg/kg	SWOS-8(1 5-3)	2 / 20	0 0002 - 0 0008	0 002	N/A	3.4 (ca)	N/A	N/A	N	BSL
	78933	2-Butanone	0 0009 (J)	0 014	mg/kg	SWOS-8(0-1 5)	10 / 20	0 001 - 0 004	0.014	N/A	730 (nc)	N/A	N/A	N	BSL
	95498	2-Chlorotoluene	0 0006	0.0006	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0.0006	N/A	16 (nc)	N/A	N/A	N	BSL, IFD
	591788	2-Hexanone	0 0011 (J)	0 0011 (J)	mg/kg	SWOS-1(1 5-3)-AVG	1 / 20	0.001 - 0 004	0 0011	N/A	N/A	N/A	N/A	N	IFD
	106434	4-Chlorotoluene	0 0008	0.0008	mg/kg	SWOS-8(1 5-3)	1 / 20	0 0002 - 0 0008	0 0008	N/A	N/A	N/A	N/A	N	IFD
	99876	4-Isopropyltoluene	0 0005	0.0008	mg/kg	SWOS-8(1.5-3)	3 / 20	0 0003 - 0 0008	0 0008	N/A	N/A	N/A	N/A	Y	FD
	71432	Benzene	0 0005	0 0005	mg/kg	SWOS-4(1.5-3)	1 / 20	0 0002 - 0 0008	0.0005	N/A	0 6 (ca)	N/A	N/A	N	BSL, IFD
	108861	Bromobenzene	0.0009	0.0009	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0.0009	N/A	2 8 (nc)	N/A	N/A	N	BSL, IFD
	75150	Carbon Disulfide	0.0006	0.0006	mg/kg	SWOS-9(1.5-3)	1 / 20	0 0003 - 0 0008	0 0006	N/A	38 (nc)	N/A	N/A	N	BSL, IFD
	87683	Hexachlorobutadiene	0 001	0 001	mg/kg	SWOS-8(1 5-3)	1 / 20	0 0002 - 0 0008	0 001	N/A	6.2 (ca)	N/A	N/A	N	BSL, IFD
	74884	Iodomethane	0.0005	0 002	mg/kg	SWOS-2(1 5-3)	6 / 20	0 0003 - 0 0008	0 002	N/A	N/A	N/A	N/A	Y	FD
	106423	m,p-Xylene	0 0008	0 0008	mg/kg	SWOS-8(1 5-3)	1 / 20	0 0002 - 0 0008	0 0008	N/A	N/A	N/A	N/A	N	IFD
	75092	Methylene Chloride	0 0008 (J)	0.0045	mg/kg	SWOS-1(1 5-3)-AVG	17 / 20	0 001 - 0 002	0 0045	N/A	9.1 (ca)	N/A	N/A	N	BSL
	104518	n-Butylbenzene	0 001	0.001	mg/kg	SWOS-8(1 5-3)	1 / 20	0 0002 - 0 0008	0 001	N/A	240 (sat)	N/A	N/A	N	BSL, IFD
	91203	Naphthalene	0 0015	0.014	mg/kg	SWOS-8(1 5-3)	4 / 20	0 0002 - 0 0008	0 014	N/A	5 6 (nc)	N/A	N/A	N	BSL
	95476	o-Xylene	0 0004	0.0004	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0.0004	N/A	N/A	N/A	N/A	N	IFD
	135988	sec-Butylbenzene	0.0007	0.0007	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0.0007	N/A	220 (sat)	N/A	N/A	N	BSL, IFD
	100425	Styrene	0 0006	0.0006	mg/kg	SWOS-8(1.5-3)	1 / 20	0 0002 - 0 0008	0.0006	N/A	1,700 (sat)	N/A	N/A	N	BSL, IFD

TABLE 3-2
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
Medium Soil
Exposure Medium: Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	98066	tert-Butylbenzene	0.0007	0.0007	mg/kg	SWOS-8(1 5-3)	1 / 20	0.0002 - 0.0008	0.0007	N/A	390 (sat)	N/A	N/A	N	BSL, IFD
	108883	Toluene	0.0003 (J)	0.0006	mg/kg	SWOS-9(0-1 5)	4 / 20	0.0003 - 0.0008	0.0006	N/A	520 (sat)	N/A	N/A	N	BSL
	75694	Trichlorofluoromethane	0.001	0.001	mg/kg	SWOS-8(1.5-3), SWOS-3(0-1 5)	2 / 20	0.0003 - 0.0008	0.001	N/A	39 (nc)	N/A	N/A	N	BSL
	1330207	Xylene (Total)	0.001	0.001	mg/kg	SWOS-8(1 5-3)	1 / 20	0.0002 - 0.0008	0.001	N/A	27 (nc)	N/A	N/A	N	BSL, IFD
	208968	Acenaphthylene	0.072 (J)	0.072 (J)	mg/kg	SWOS-3(1 5-3)	1 / 20	0.35 - 0.45	0.072	N/A	N/A	N/A	N/A	N	IFD
	120127	Anthracene	0.098 (J)	0.22 (J)	mg/kg	SWOS-3(1 5-3)	2 / 20	0.35 - 0.45	0.22	N/A	2,200 (nc)	N/A	N/A	N	BSL
	56553	Benzo(a)anthracene	0.06 (J)	0.57	mg/kg	SWOS-3(1 5-3)	18 / 20	0.39 - 0.42	0.57	N/A	0.62 (ca)	N/A	N/A	N	BSL
	50328	Benzo(a)pyrene	0.063 (J)	0.53	mg/kg	SWOS-3(1.5-3)	18 / 20	0.39 - 0.42	0.53	N/A	0.062 (ca)	N/A	N/A	Y	ASL
	205992	Benzo(b)fluoranthene	0.055 (J)	0.73	mg/kg	SWOS-3(1.5-3)	17 / 20	0.39 - 0.42	0.73	N/A	0.62 (ca)	N/A	N/A	Y	ASL
	191242	Benzo(g,h,i)perylene	0.039 (J)	0.22 (J)	mg/kg	SWOS-3(1 5-3)	11 / 20	0.35 - 0.44	0.22	N/A	N/A	N/A	N/A	Y	FD
	207089	Benzo(k)fluoranthene	0.04 (J)	0.36 (J)	mg/kg	SWOS-3(1 5-3)	15 / 20	0.38 - 0.42	0.36	N/A	6.2 (ca)	N/A	N/A	N	BSL
	86748	Carbazole	0.05 (J)	0.05 (J)	mg/kg	SWOS-3(1 5-3)	1 / 20	0.35 - 0.45	0.05	N/A	24 (ca)	N/A	N/A	N	BSL, IFD
	218019	Chrysene	0.045 (J)	0.58	mg/kg	SWOS-3(1 5-3)	17 / 20	0.39 - 0.42	0.58	N/A	62 (ca)	N/A	N/A	N	BSL
	53703	Dibenzo(a,h)anthracene	0.053 (J)	0.068 (J)	mg/kg	SWOS-3(1.5-3)	2 / 20	0.35 - 0.45	0.068	N/A	0.062 (ca)	N/A	N/A	Y	ASL
	132849	Dibenzofuran	0.045 (J)	0.045 (J)	mg/kg	SWOS-3(1 5-3)	1 / 20	0.35 - 0.45	0.045	N/A	29 (nc)	N/A	N/A	N	BSL, IFD
	206440	Fluoranthene	0.042 (J)	1.2	mg/kg	SWOS-3(1 5-3)	19 / 20	0.39	1.2	N/A	230 (nc)	N/A	N/A	N	BSL
	86737	Fluorene	0.068 (J)	0.068 (J)	mg/kg	SWOS-3(1 5-3)	1 / 20	0.35 - 0.45	0.068	N/A	270 (nc)	N/A	N/A	N	BSL, IFD
	193395	Indeno(1,2,3-cd)pyrene	0.039 (J)	0.25 (J)	mg/kg	SWOS-3(1.5-3)	9 / 20	0.35 - 0.44	0.25	N/A	0.62 (ca)	N/A	N/A	N	BSL
	85018	Phenanthrene	0.047 (J)	0.83	mg/kg	SWOS-3(1 5-3)	15 / 20	0.39 - 0.42	0.83	N/A	N/A	N/A	N/A	Y	FD
	129000	Pyrene	0.043 (J)	1	mg/kg	SWOS-3(1.5-3)	18 / 20	0.39 - 0.42	1	N/A	230 (nc)	N/A	N/A	N	BSL
	7439954	Magnesium	2020 (J)	5280 (J)	mg/kg	SWOS-1(0-1 5)	19 / 19	-	5,280	2,240	N/A	N/A	N/A	N	NUT
	7429905	Aluminum	8,840	18,000	mg/kg	SWOS-3(1 5-3)	20 / 20	-	18,000	11,900	7,600 (nc)	N/A	N/A	Y	ASL
	7440380	Antimony	0.18 (J)	2.1 (J)	mg/kg	SWOS-9(1.5-3)	8 / 20	0.14 - 0.2	2.1	0.67	3.1 (nc)	N/A	N/A	N	BSL
	7440382	Arsenic	4.3	16	mg/kg	SWOS-9(0-1 5)	20 / 20	-	16	5.55	0.39 (ca)	N/A	N/A	Y	ASL
	7440393	Barium	16.2 (J)	50.4 (J)	mg/kg	SWOS-5(1 5-3)	20 / 20	-	50.4	38.5	540 (nc)	N/A	N/A	N	BSL
	7440417	Beryllium	0.22 (J)	0.49	mg/kg	SWOS-7(0-1.5)	20 / 20	-	0.49	0.439	15 (nc)	N/A	N/A	N	BSL
	7440439	Cadmium	0.25 (J)	0.81 (J)	mg/kg	SWOS-3(1 5-3)	20 / 20	-	0.81	0.7	3.7 (nc)	N/A	N/A	N	BSL
	7440702	Calcium	401	1,910	mg/kg	SWOS-8(0-1.5)	20 / 20	-	1,910	1,220	N/A	N/A	N/A	N	NUT
	7440473	Chromium	10.6	21.7	mg/kg	SWOS-3(1 5-3)	20 / 20	-	21.7	20.2	30 (ca)	N/A	N/A	N	BSL
	7440484	Cobalt	7.3 (J)	18.1 (J)	mg/kg	SWOS-5(1 5-3)	20 / 20	-	18.1	9.01	900 (ca)	N/A	N/A	N	BSL

TABLE 3-2
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
	7440508	Copper	10.9	68.7	mg/kg	SWOS-8(0-1.5)	20 / 20	-	68.7	23.8	310 (nc)	N/A	N/A	N	BSL
	7439896	Iron	16,800	45,000	mg/kg	SWOS-3(1.5-3)	20 / 20	-	45,000	23,200	2,300 (nc)	N/A	N/A	N	NUT
	7439921	Lead	9.4 (J)	68.8 (J)	mg/kg	SWOS-7(0-1.5)	20 / 20	-	68.8	48.8	40 (nc)	N/A	N/A	Y	ASL
	7439965	Manganese	192 (J)	682 (J)	mg/kg	SWOS-5(1.5-3)	20 / 20	-	682	372	180 (nc)	N/A	N/A	Y	ASL
	7439976	Mercury	0.026 (J)	0.3	mg/kg	SWOS-6(1.5-3)	20 / 20	-	0.3	0.189	2.3 (nc)	N/A	N/A	N	BSL
	7440020	Nickel	13.2	32.1	mg/kg	SWOS-3(1.5-3)	20 / 20	-	32.1	17.4	160 (nc)	N/A	N/A	N	BSL
	7440097	Potassium	264	661.5	mg/kg	SWOS-1(1.5-3)-AVG	20 / 20	-	661.5	312	N/A	N/A	N/A	N	NUT
	7782492	Selenium	0.29	1.3	mg/kg	SWOS-2(0-1.5)	11 / 20	0.14 - 0.18	1.3	N/A	39 (nc)	N/A	N/A	N	BSL
	7440224	Silver	3.7 (J)	6.7 (J)	mg/kg	SWOS-5(1.5-3)	20 / 20	-	6.7	N/A	39 (nc)	N/A	N/A	N	BSL
	7440235	Sodium	32.9 (J)	89.7 (J)	mg/kg	SWOS-5(1.5-3)	20 / 20	-	89.7	N/A	N/A	N/A	N/A	N	NUT
	7440822	Vanadium	13.4	29.1	mg/kg	SWOS-3(1.5-3)	20 / 20	-	29.1	22.6	55 (nc)	N/A	N/A	N	BSL
	7440686	Zinc	42.8 (J)	105 (J)	mg/kg	SWOS-3(1.5-3)	20 / 20	-	105	225	2,300 (nc)	N/A	N/A	N	BSL, BKG

Footnote Instructions

- (1) J - Estimated
- (2) Maximum detected concentration used for screening.
- (3) Tetra Tech NUS, 2000. Background Soil Investigation for Old Fire Fighting Training Area, Naval Station Newport, Newport, Rhode Island. August. - Recommended Surface Soil Background Concentrations
- (4) USEPA, 2002. Region 9 Preliminary Remediation Goals Table. October. - ca = PRG based on carcinogenic effects; nc = PRG based on non-carcinogenic effects; sat = PRG based on soil saturation
- (5) BSL = Below Screening Level, IFD = Infrequently Detected, NUT = Essential Nutrient, BKG = Background, ASL = Above Screening Level, FD = Frequently Detected

TABLE 3-3
EXPOSURE POINT CONCENTRATION SUMMARY
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (3)	Rationale
Soil	4-Isopropyltoluene	mg/kg	0.0003	0.00044 (non-parametric)	0.0008	0.00044	mg/kg	95% Cheb	UCL < MAX
	Iodomethane	mg/kg	0.000482	0.000844 (non-parametric)	0.002	0.000844	mg/kg	95% Cheb	UCL < MAX
	Benzo(a)pyrene	mg/kg	0.164	0.216 (lognormal)	0.53	0.216	mg/kg	95% H-UCL	UCL < MAX
	Benzo(b)fluoranthene	mg/kg	0.211	0.286 (lognormal)	0.73	0.286	mg/kg	95% H-UCL	UCL < MAX
	Benzo(g,h,i)perylene	mg/kg	0.144	0.246 (non-parametric)	0.22 (J)	0.22	mg/kg	MAX	UCL > MAX
	Dibenzo(a,h)anthracene	mg/kg	0.183	0.256 (non-parametric)	0.066 (J)	0.066	mg/kg	MAX	UCL > MAX
	Phenanthrene	mg/kg	0.18	0.255 (lognormal)	0.83	0.255	mg/kg	95% H-UCL	UCL < MAX
	Aluminum	mg/kg	11,562	12,475 (lognormal)	18,000	12,475	mg/kg	95% H-UCL	UCL < MAX
	Arsenic	mg/kg	8.14	9.27 (lognormal)	16	9.27	mg/kg	95% H-UCL	UCL < MAX
	Lead	mg/kg	36.4	42 (normal)	68.8 (N*)	42	mg/kg	95% UCL	UCL < MAX
	Manganese	mg/kg	351	401 (lognormal)	682 (E)	401	mg/kg	95% H-UCL	UCL < MAX

Notes:

(1) 1/2 the detection limit was used for samples with non-detect concentrations.

(2) normal = data set is normally distributed; lognormal = data set is lognormally distributed; non-parametric = data set is neither normally nor lognormally distributed

(3) 95% Cheb = 95% Chebyshev (MVUE) UCL; 95% H-UCL = 95% UCL assuming data are lognormal; MAX = Maximum Detected Value; 95% UCL = 95% Student's t UCL

3.4 Exposure Assessment

The exposure assessment quantitatively describes the most potentially significant pathways through which the construction worker may contact contamination in the soil at the site. Equations defining the amount of chemical intake or dose received for each identified exposure pathway are shown in Table 3-4. The parameter values used in the intake equations which quantify the exposure scenarios were developed for the construction worker using USEPA risk assessment guidance (USEPA, 1989, 1995, 1996, 1997b, 1997c). An explicit effort was made to maintain a consistency of these reasonable maximum exposure assumptions with the assumptions previously made for similar assessments at other sites at NAVSTA Newport. The parameter values used in the risk assessment are shown in Table 3-4.

3.5 Toxicity Assessment

The toxicological information used in this risk assessment was based on non-carcinogenic (threshold) and carcinogenic (non-threshold) effects caused by exposure to chemicals that have been observed in humans and/or laboratory animals associated with a particular dose of that compound. The toxicological information is used in conjunction with the exposure assessment to characterize the level of risk associated with each COPC via each identified exposure pathway. Chemical-specific toxicological parameters (i.e., non-carcinogenic reference doses [RfDs]) and cancer slope factors [SFs]) were obtained from established USEPA sources according to the following hierarchy.

1. USEPA's Integrated Risk Information System (IRIS) on-line database (USEPA, 2003b).
2. Health Effects Assessment Summary Table (HEAST), (USEPA, 1997a).
3. Superfund Technical Support Center at the National Center for Environmental Assessment (NCEA).

These sources of toxicological information provide data applicable to the assessment of oral and inhalation pathways. The methodologies for evaluating dermal absorption are based on an estimation of absorbed dose while the IRIS-verified RfDs are typically based on an administered dose. Therefore, an adjustment of the oral toxicological factor to represent an absorbed rather than an administered dose is necessary to maintain consistency. Toxicological factors for the dermal absorption pathway were calculated from the oral values using an oral-to-dermal adjustment factor in accordance with USEPA protocol. The oral-to-dermal adjustment factor is based on the gastrointestinal (GI) absorption efficiencies listed in USEPA RAGS Part E, Exhibit 4.1 (USEPA, 2001b). The adjustment accounts for the absorption efficiency in the critical clinical or epidemiological study forming the basis of the published toxicity factor. The magnitude of the toxicity factor adjustment is inversely proportional to the absorption fraction in the critical study. As the absorption efficiency decreases, the difference between the absorbed dose and administered dose increases. Consistent with USEPA, 2001b, an adjustment was made when the following conditions were met:

- The toxicity value derived from the critical study was based on an administered dose (e.g., delivery in diet or by gavage) in its study design; and
- A scientifically defensible database demonstrates that the GI absorption of the chemical in question from a media (e.g., water, feed) similar to the one employed in the critical study is significantly less than 100% (i.e., <50%).

If these conditions were not met, complete (i.e., 100%) absorption was assumed and no adjustment of the oral toxicity value was made to obtain a toxicity value to be used for the dermal absorption route.

TABLE 3-4
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/Reference	Intake Equation/Model Name
Incidental Ingestion	Construction Worker	Adult	Soil	CS	Chemical Concentration in Soil	Chemical-specific	mg/kg	See EPCs	Chronic Daily Intake (mg/kg-day) = $CS \times IR-S \times FI \times EF \times ED \times CF1$ BW x AT
				IR-S	Ingestion Rate of Soil	480	mg/day	(1)	
				EF	Exposure Frequency	48	days/year	(3)	
				ED	Exposure Duration	1	year	(4)	
				BW	Body Weight	70	kg	(5)	
				CF1	Conversion Factor 1	1E-06	kg/mg	-	
				AT-N	Averaging Time (Non-Cancer)	365	days	(6)	
Dermal Absorption	Construction Worker	Adult	Soil	AT-C	Averaging Time (Cancer)	25,550	days	(6)	Dermally Absorbed Dose (mg/kg-day) = $CS \times SA \times SSAF \times DABS \times EV \times EF \times ED \times CF1$ BW x AT
				CS	Chemical Concentration in Soil	Chemical-specific	mg/kg	See EPCs	
				SA	Skin Surface Area Available for Contact	7,014	cm ²	(7)	
				SSAF	Soil-to-Skin Adherence Factor	0.08	mg/cm ² /event	(8)	
				DABS	Dermal Absorption Factor (Solid)	Chemical-specific	unitless	(9)	
				EV	Event Frequency	1	events/day	(10)	
				EF	Exposure Frequency	48	days/year	(3)	
				ED	Exposure Duration	1	year	(4)	
				BW	Body Weight	70	kg	(5)	
				CF1	Conversion Factor 1	1E-06	kg/mg	-	
Inhalation of Particulates	Construction Worker	Adult	Soil	AT-N	Averaging Time (Non-Cancer)	365	days	(6)	Chronic Daily Intake (mg/kg-day) = $CS \times 1/PEF \times IN \times ET \times EF \times ED$ BW x AT
				AT-C	Averaging Time (Cancer)	25,550	days	(6)	
				CS	Chemical Concentration in Soil	Chemical-specific	mg/kg	See EPCs	
				PEF	Particulate Emission Factor from Soil	1.32E+09	m ³ /kg	(11)	
				IN	Inhalation Rate	3.3	m ³ /hr	(5)	
				ET	Exposure Time	8	hours/day	(12)	
				EF	Exposure Frequency	48	days/year	(3)	
				ED	Exposure Duration	1	year	(4)	
				BW	Body Weight	70	kg	(5)	
				AT-N	Averaging Time (Non-Cancer)	365	days	(6)	
				AT-C	Averaging Time (Cancer)	25,550	days	(6)	

TABLE 3-4 - Continued

Notes:

- (1) USEPA, 1994. EPA Region I, Risk Updates. August 1994, Volume II
- (2) Professional Judgement. Fraction Ingested is assumed to be 100% from source.
- (3) Professional Judgement. Exposure Frequency based on 6 days per week for 8 weeks (2 months) = 48 days
- (4) Professional Judgement. 1 year of exposure.
- (5) USEPA, 1997. Exposure Factors Handbook. Update to Exposure Factors Handbook. EPA/600/8-89/043 - May 1989. Office of Research and Development.
- (6) USEPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response.
- (7) Surface Area represented by hands, head, feet, forearms, and lower legs.
- (8) USEPA, 1997. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Supplemental Guidance. Dermal Risk Assessment (Interim Guidance). EPA Region I
- (9) USEPA, 1995. Assessing Dermal Exposure from Soil, EPA Region III Technical Guidance Manual, EPA/903-K-95-003. December
- (10) Professional Judgement. 1 event per day.
- (11) USEPA, 1996. Soil Screening Guidance. Users Guide. EPA 935.4-23. Office of Solid Waste and Emergency Response
- (12) Professional Judgement. 8 hours per day of exposure based on an average workday

A summary of the relevant non-cancer and cancer toxicological factors for the COPCs is presented in Tables 3-5, 3-6, 3-7, and 3-8. The toxicological factors for some surrogate chemicals were conservatively applied when other toxicological information was not available for a chemical, as noted on the tables.

The toxicities of the PAH compounds were evaluated using toxicity equivalency factors (TEFs). Benzo(a)pyrene is considered to be one of the most potent PAH carcinogens. As such, the toxicity of the other carcinogenic PAHs is typically expressed relative to the toxicity of benzo(a)pyrene through the use of a TEF. The TEF is the ratio of the toxicity of the carcinogenic PAH to the toxicity of benzo(a)pyrene. The TEFs for the carcinogenic PAHs are shown in the table below (USEPA, 1994). The slope factor used in the risk calculations for each carcinogenic PAH was the slope factor for benzo(a)pyrene multiplied by the TEF for that PAH. These calculated slope factors are shown on Table 3-7.

<u>Detected PAHs</u>	<u>Toxicity Equivalency Factor</u>
Benzo(a)pyrene	1.0
Benzo(b)fluoranthene	0.1
Dibenz(a,h)anthracene	1.0

3.6 Risk Characterization

Quantitative evaluation of risks involves combining exposure point concentrations, exposure scenarios, and toxicity values using methods defined by USEPA to calculate potential carcinogenic and non-carcinogenic risks. Potential health risks were calculated for the construction worker to assess exposures to contaminant levels in surface and subsurface soil along the planned route of the subsurface utilities in the parking lot area.

Chronic Daily Intakes (CDIs) for the construction worker were calculated for each ingestion, dermal absorption, and inhalation exposure pathway. The equations for calculating intake for each exposure pathway are shown on Table 3-4. CDIs are expressed as the amount of a chemical an individual would be exposed to per unit body weight per day (i.e., mg/kg-day). The CDIs are averaged over a lifetime (70 years) for carcinogens, and over the exposure duration for non-carcinogens (USEPA, 1989).

For non-carcinogens, exposure pathways were evaluated by comparing chemical-specific CDIs to their associated RfDs. Potential non-carcinogenic effects are evaluated as the ratio of the CDI to the RfD. The sum of all chemical-specific CDI/RfD ratios, which are referred to as Hazard Quotients (HQs), for the COPCs is called the Hazard Index (HI) and is calculated as shown below:

$$HI = \sum_{i=1}^n \frac{CDI_i}{RfD_i}$$

where:

CDI _i	=	Chronic daily intake for COPC i (mg/kg-day)
HI	=	Hazard Index (unitless)
n	=	Number of COPCs in each exposure medium (unitless)
RfD _i	=	Reference dose for COPC i (mg/kg-day)

An HI less than 1.0 is unlikely to be associated with adverse health effects and is therefore less likely to be of concern than an HI greater than 1.0. In addition, the effect/target organ-specific HIs were evaluated (which assumes that two chemicals that produce adverse effects on the same target organ are dose additive). Table 3-9 presents the EPC, intake value, RfD and individual hazard quotients for each exposure pathway for the construction worker.

TABLE 3-5
NON-CANCER TOXICITY DATA – ORAL/DERMAL
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
4-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene (2)	Chronic	3.0E-02	mg/kg-day	100%	3.0E-02	mg/kg-day	Kidney	3000	IRIS	08/25/03
Benzo(b)fluoranthene (2)	Chronic	3.0E-02	mg/kg-day	100%	3.0E-02	mg/kg-day	Kidney	3000	IRIS	08/25/03
Benzo(g,h,i)perylene (2)	Chronic	3.0E-02	mg/kg-day	100%	3.0E-02	mg/kg-day	Kidney	3000	IRIS	08/25/03
Dibenzo(a,h)anthracene (2)	Chronic	3.0E-02	mg/kg-day	100%	3.0E-02	mg/kg-day	Kidney	3000	IRIS	08/25/03
Phenanthrene (3)	Chronic	3.0E-01	mg/kg-day	100%	3.0E-01	mg/kg-day	None	3000	IRIS	08/25/03
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	Chronic	3.0E-04	mg/kg-day	100%	3.0E-04	mg/kg-day	Skin	3	IRIS	08/25/03
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	Chronic	1.4E-01	mg/kg-day	4%	5.6E-03	mg/kg-day	Nervous System	1	IRIS	08/25/03

Notes:

NA = Not Applicable

(1) USEPA, 2001b. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Interim.

(2) Pyrene used as a surrogate for toxicological values for benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, and dibenzo(a,h)anthracene.

(3) Anthracene used as a surrogate for toxicological values for phenanthrene.

TABLE 3-6
NON-CANCER TOXICITY DATA – INHALATION
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
4-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	Chronic	5.0E-05	mg/m ³	1.4E-05	mg/kg-day	Nervous System	1000	IRIS	8/25/2003

Notes:

NA = Not Applicable

TABLE 3-7
CANCER TOXICITY DATA – ORAL/DERMAL
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence/ Cancer Guideline Description (3)	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
4-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	7.3E+00	(mg/kg-day) ⁻¹	100%	7.3E+00	(mg/kg-day) ⁻¹	B2	IRIS	08/25/03
Benzo(b)fluoranthene (2)	7.3E-01	(mg/kg-day) ⁻¹	100%	7.3E-01	(mg/kg-day) ⁻¹	B2	IRIS	08/25/03
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	D	IRIS	08/25/03
Dibenzo(a,h)anthracene (2)	7.3E+00	(mg/kg-day) ⁻¹	100%	7.3E+00	(mg/kg-day) ⁻¹	B2	IRIS	08/25/03
Phenanthrene	NA	NA	NA	NA	NA	D	IRIS	08/25/03
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	1.5E+00	(mg/kg-day) ⁻¹	100%	1.5E+00	(mg/kg-day) ⁻¹	A	IRIS	08/25/03
Lead	NA	NA	NA	NA	NA	B2	IRIS	08/25/03
Manganese	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

(1) USEPA, 2001b. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).

(2) Benzo(a)pyrene toxic equivalency factors applied to slope factor for benzo(b)fluoranthene, and dibenzo(a,h)anthracene.

(3) Weight of Evidence/Cancer Guideline Descriptions:

A - Human carcinogen

B1 - Probable human carcinogen - Indicates that limited human data are available

B2 - Probable human carcinogen - Indicates sufficient evidence in animals and
inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

TABLE 3-8
CANCER TOXICITY DATA – INHALATION
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description (1)	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
4-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA
Aluminum	NA	NA	NA	NA	NA	NA	NA
Arsenic	4.3E+00	(mg/m ³) ⁻¹	1.5E+01	(mg/kg-day) ⁻¹	A	IRIS	8/25/2003
Lead	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA

Notes:

(1) Weight of Evidence/Cancer Guideline Descriptions:

- A - Human carcinogen
- B1 - Probable human carcinogen - Indicates that limited human data are available
- B2 - Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans
- C - Possible human carcinogen
- D - Not classifiable as a human carcinogen
- E - Evidence of noncarcinogenicity

TABLE 3-9
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
 Receptor Population: Construction Worker
 Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Soil	Soil	Soil	Incidental Ingestion	4-Isopropyltoluene	0.00044	mg/kg	5.7E-12	mg/kg-day	NA	NA	—	4.0E-10	mg/kg-day	NA	NA	—
				Iodomethane	0.000844	mg/kg	1.1E-11	mg/kg-day	NA	NA	—	7.6E-10	mg/kg-day	NA	NA	—
				Benzo(a)pyrene	0.218	mg/kg	2.8E-09	mg/kg-day	7.3E+00	(mg/kg-day) ⁻¹	2.0E-08	1.9E-07	mg/kg-day	3.0E-02	mg/kg-day	6.5E-06
				Benzo(b)fluoranthene	0.286	mg/kg	3.7E-09	mg/kg-day	7.3E-01	(mg/kg-day) ⁻¹	2.7E-09	2.6E-07	mg/kg-day	3.0E-02	mg/kg-day	8.6E-08
				Benzo(g,h,i)perylene	0.22	mg/kg	2.8E-09	mg/kg-day	NA	NA	—	2.0E-07	mg/kg-day	3.0E-02	mg/kg-day	6.6E-06
				Dibenzo(a,h)anthracene	0.066	mg/kg	8.5E-10	mg/kg-day	7.3E+00	(mg/kg-day) ⁻¹	6.2E-09	8.0E-08	mg/kg-day	3.0E-02	mg/kg-day	2.0E-06
				Phenanthrene	0.255	mg/kg	3.3E-09	mg/kg-day	NA	NA	—	2.3E-07	mg/kg-day	3.0E-01	mg/kg-day	7.7E-07
				Aluminum	12475	mg/kg	1.6E-04	mg/kg-day	NA	NA	—	1.1E-02	mg/kg-day	NA	NA	—
				Arsenic	9.27	mg/kg	1.2E-07	mg/kg-day	1.5E+00	(mg/kg-day) ⁻¹	1.8E-07	8.4E-06	mg/kg-day	3.0E-04	mg/kg-day	2.8E-02
				Lead	42	mg/kg	5.4E-07	mg/kg-day	NA	NA	—	3.8E-05	mg/kg-day	NA	NA	—
				Manganese	401	mg/kg	5.2E-06	mg/kg-day	NA	NA	—	3.6E-04	mg/kg-day	1.4E-01	mg/kg-day	2.6E-03
			Exp. Route Total								2.1E-07					3.0E-02
			Dermal Absorption	4-Isopropyltoluene	0.00044	mg/kg	N/A	N/A	NA	NA	—	N/A	N/A	NA	NA	—
				Iodomethane	0.000844	mg/kg	N/A	N/A	NA	NA	—	N/A	N/A	NA	NA	—
				Benzo(a)pyrene	0.218	mg/kg	4.2E-10	mg/kg-day	7.3E+00	(mg/kg-day) ⁻¹	3.1E-09	3.0E-08	mg/kg-day	3.0E-02	mg/kg-day	9.9E-07
				Benzo(b)fluoranthene	0.286	mg/kg	5.6E-10	mg/kg-day	7.3E-01	(mg/kg-day) ⁻¹	4.1E-10	3.9E-08	mg/kg-day	3.0E-02	mg/kg-day	1.3E-06
				Benzo(g,h,i)perylene	0.22	mg/kg	4.3E-10	mg/kg-day	NA	NA	—	3.0E-08	mg/kg-day	3.0E-02	mg/kg-day	1.0E-06
				Dibenzo(a,h)anthracene	0.066	mg/kg	1.3E-10	mg/kg-day	7.3E+00	(mg/kg-day) ⁻¹	9.4E-10	9.0E-09	mg/kg-day	3.0E-02	mg/kg-day	3.0E-07
				Phenanthrene	0.255	mg/kg	5.0E-10	mg/kg-day	NA	NA	—	3.5E-08	mg/kg-day	3.0E-01	mg/kg-day	1.2E-07
				Aluminum	12475	mg/kg	N/A	N/A	NA	NA	—	N/A	N/A	NA	NA	—
				Arsenic	9.27	mg/kg	4.2E-09	mg/kg-day	1.5E+00	(mg/kg-day) ⁻¹	6.3E-09	2.9E-07	mg/kg-day	3.0E-04	mg/kg-day	9.8E-04
				Lead	42	mg/kg	N/A	N/A	NA	NA	—	N/A	N/A	NA	NA	—
				Manganese	401	mg/kg	N/A	N/A	NA	NA	—	N/A	N/A	5.60E-03	mg/kg-day	—
			Exp. Route Total								1.1E-08					9.8E-04

TABLE 3-9
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RID/RIC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
			Inhalation of Particulates	4-Isopropyltoluene	0.00044	mg/kg	2.4E-16	mg/kg-day	NA	NA	—	1.7E-14	mg/kg-day	NA	NA	—
				Iodomethane	0.000844	mg/kg	4.5E-16	mg/kg-day	NA	NA	—	3.2E-14	mg/kg-day	NA	NA	—
				Benzo(a)pyrene	0.216	mg/kg	1.2E-13	mg/kg-day	NA	NA	—	8.1E-12	mg/kg-day	NA	NA	—
				Benzo(b)fluoranthene	0.286	mg/kg	1.5E-13	mg/kg-day	NA	NA	—	1.1E-11	mg/kg-day	NA	NA	—
				Benzo(g,h,i)perylene	0.22	mg/kg	1.2E-13	mg/kg-day	NA	NA	—	8.3E-12	mg/kg-day	NA	NA	—
				Dibenzo(a,h)anthracene	0.066	mg/kg	3.5E-14	mg/kg-day	NA	NA	—	2.5E-12	mg/kg-day	NA	NA	—
				Phenanthrene	0.255	mg/kg	1.4E-13	mg/kg-day	NA	NA	—	9.6E-12	mg/kg-day	NA	NA	—
				Aluminum	12475	mg/kg	6.7E-09	mg/kg-day	NA	NA	—	4.7E-07	mg/kg-day	NA	NA	—
				Arsenic	9.27	mg/kg	5.0E-12	mg/kg-day	1.5E+01	(mg/kg-day) ⁻¹	7.5E-11	3.5E-10	mg/kg-day	NA	NA	—
				Lead	42	mg/kg	2.3E-11	mg/kg-day	NA	NA	—	1.6E-09	mg/kg-day	NA	NA	—
		Manganese	401	mg/kg	2.2E-10	mg/kg-day	NA	NA	—	1.5E-08	mg/kg-day	1.4E-05	mg/kg-day	1.1E-03		
		Exp Route Total										7.5E-11				1.1E-03
		Exposure Point Total										2.2E-07				3.3E-02
		Exposure Medium Total										2.2E-07				3.3E-02
Medium Total										2.2E-07				3.3E-02		
Total of Receptor Risks Across All Media											2.2E-07	Total of Receptor Hazards Across All Media				3.3E-02

The potential incremental lifetime cancer risk due to exposure to a specific carcinogenic compound is calculated by multiplying chemical-specific CDIs with their associated SFs. The sum of all chemical-specific CDI*SF products for the COPCs is called the Excess Lifetime Cancer Risk (ELCR) and is calculated as shown below:

$$ELCR = \sum_{i=1}^n CDI_i \cdot SF_i$$

where:

CDI_i = Chronic daily intake for COPC i (mg/kg-day)
 $ELCR$ = Excess lifetime cancer risk (unitless)
 n = Number of COPCs in each exposure medium (unitless)
 SF_i = Slope factor for COPC i (mg/kg-day)⁻¹

For the purposes of this assessment, cancer risks for exposure to multiple carcinogenic contaminants were assumed to be additive. USEPA has established that the acceptable target risk range is between 1×10^{-6} and 1×10^{-4} . An ELCR below or within this range is unlikely to be associated with cancer effects and is less likely to be of concern than an ELCR exceeding this range. Table 3-9 presents the EPC, intake value, SF, and individual carcinogenic risks for each exposure pathway.

The results of the carcinogenic risk and HI calculations for each receptor are summarized on Table 3-10. Intake calculations are documented in Appendix B. The construction worker evaluated in the risk assessment was calculated to have an excess lifetime cancer risk (ELCR) of 2.2×10^{-7} . This risk is lower than the most stringent endpoint of the USEPA's acceptable target risk range (i.e., 10^{-6} to 10^{-4} ELCR). The construction worker evaluated in this risk assessment was calculated to have a hazard index (HI) of 0.033, which is well below the USEPA's Threshold HI of 1.0.

3.7 Uncertainty Analysis

All risk assessments contain elements of uncertainty. Sources and characteristics of uncertainties are examined in this section to provide perspective for interpreting the results and level of conservatism inherent in the risk estimates and the underlying assumptions. The purpose of highlighting and discussing uncertainty is to assist in risk management decisions.

Most assumptions made in developing the risk estimates were by design biased toward health protectiveness, that is, toward overestimating rather than underestimating chemical exposure and risk. There is, therefore, a reasonable degree of certainty that actual risks to a construction worker exposed to site soil during construction will not be greater than those estimated in the risk assessment and are likely to be much lower. Specific uncertainties are highlighted below:

- The Adult Lead Model (USEPA, 2003a) was not used in this analysis to assess potential exposures to lead in soil because the duration/frequency of exposure of the construction worker to the site was less than the 90 days/year minimum required for the model to be valid. The Adult Lead Model estimates the blood lead levels in a fetus based on ingested contaminated soil lead levels by an expectant adult mother. It is highly unlikely that an expectant mother would be a construction worker installing utilities at the site. Total non-carcinogenic risks to the construction worker are not likely to be underestimated due to the lack of a detailed quantitative assessment of this COPC.

- Toxicological surrogates were used for a few of the COPCs. Use of the selected surrogates was designed to purposefully generate higher risk estimates than not considering those COPCs at all, and is conservative from that perspective. It is unknown how the toxicity of the assigned surrogates relates to the actual toxicity of the COPC that they represent.
- The background data considered for the site was the background data collected for the OFFTA, an area also within NAVSTA Newport. While the samples were not collected immediately adjacent to the SWOS parking lot area, the data would appear to be representative of background conditions in the local region. As the background data played a very limited role in this assessment (i.e., no chemicals were screened out based solely on the comparison to the background data), the impact of using these data rather than collecting additional samples closer to the site is minimal.

TABLE 3-10
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient					
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total	
Soil	Soil	Soil	4-Isopropyltoluene	-	-	-	-	0.0E+00	NA	-	-	-	0.0E+00	
			Iodomethane	-	-	-	-	0.0E+00	NA	-	-	-	0.0E+00	
			Benzo(a)pyrene	2.0E-08	-	3.1E-09	-	2.3E-08	Kidney	6.5E-06	-	9.9E-07	7.5E-06	
			Benzo(b)fluoranthene	2.7E-09	-	4.1E-10	-	3.1E-09	Kidney	8.6E-06	-	1.3E-06	9.9E-06	
			Benzo(g,h,i)perylene	-	-	-	-	0.0E+00	Kidney	6.6E-06	-	1.0E-06	7.6E-06	
			Dibenzo(a,h)anthracene	6.2E-09	-	9.4E-10	-	7.1E-09	Kidney	2.0E-06	-	3.0E-07	2.3E-06	
			Phenanthrene	-	-	-	-	0.0E+00	None	7.7E-07	-	1.2E-07	8.8E-07	
			Aluminum	-	-	-	-	0.0E+00	NA	-	-	-	0.0E+00	
			Arsenic	1.8E-07	7.5E-11	6.3E-09	-	1.9E-07	Skin	2.8E-02	-	9.8E-04	2.9E-02	
			Lead	-	-	-	-	0.0E+00	NA	-	-	-	0.0E+00	
			Manganese	-	-	-	-	0.0E+00	Nervous System	2.6E-03	1.1E-03	-	3.6E-03	
			Chemical Total	2.1E-07	7.5E-11	1.1E-08	0.0E+00	2.2E-07		3.0E-02	1.1E-03	9.8E-04	3.3E-02	
		Exposure Point Total											3.3E-02	
	Exposure Medium Total											3.3E-02		
Medium Total													3.3E-02	
Receptor Total				Receptor Risk Total					Receptor HI Total					3.3E-02

Total Kidney HI Across All Media = 2.7E-05
Total Skin HI Across All Media = 2.9E-02
Total Nervous System HI Across All Media = 3.6E-03

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Appendix A
Data Quality Review Details

TABLE OF CONTENTS

1.0	RESULTS	A-1
1.1	Holding Times	A-1
1.2	Laboratory, Preparation and Trip Blanks.....	A-1
1.2.1	VOCs	A-1
1.2.2	SVOCs	A-1
1.3	Field and Laboratory Duplicate Precision	A-1
1.3.1	VOCs	A-1
1.3.2	SVOCs	A-1
1.3.3	PAHs.....	A-2
1.3.4	Metals	A-2
1.4	MS/MSD Recovery and Relative Percent Difference (RPD)	A-2
1.4.1	SVOCs	A-3
1.4.2	PAHs.....	A-3
1.4.3	Metals	A-3
1.5	Surrogate Standard Recoveries	A-4
1.5.1	VOCs	A-4
1.5.2	SVOCs	A-4
1.5.3	Pesticides	A-4
1.5.4	PCBs	A-5
1.6	Laboratory Control Samples	A-5
1.6.1	VOCs	A-5
1.6.2	SVOCs	A-5
1.6.3	PAHs.....	A-5
1.6.4	Pesticides	A-5
1.6.5	Metals	A-5
1.7	Internal Standard Areas	A-7
1.7.1	VOCs	A-7
1.7.2	SVOCs	A-7
1.8	PCB and Pesticide Target Compound Identification	A-8
1.8.1	ICP Serial Dilutions.....	A-8

LIST OF TABLES

Table A-1	MS/MSD Recovery and Relative Percent Difference for VOCs.....	A-2
Table A-2	MS/MSD Recovery and Relative Percent Difference for SVOCs.....	A-3
Table A-3	Surrogate Standard Recoveries for VOCs	A-4
Table A-4	Surrogate Standard Recoveries for SVOCs	A-4
Table A-5	Surrogate Standard Recoveries for Pesticides	A-4
Table A-6	Surrogate Standard Recoveries for PCBs	A-5
Table A-7	Laboratory Control Samples for VOCs	A-5
Table A-8	Laboratory Control Samples for SVOCs	A-6
Table A-9	Internal Standard Areas for VOCs	A-7
Table A-10	Internal Standard Areas for SVOCs.....	A-7
Table A-11	PCB and Pesticide Target Compound Identification	A-8

1.0 RESULTS

1.1 Holding Times

All analyses were performed within Method specified holding times.

1.2 Laboratory, Preparation and Trip Blanks

1.2.1 VOCs

Acetone is reported at 5 ug/Kg in the laboratory method blank for SDG B1235 and SDG B1229. All positive results for acetone in the samples of SDG B1235 and SDG B1229 less than 50 ug/Kg are qualified as non detect due to the potential false positives from laboratory contamination.

An equipment rinsate blank sample collected on 7/28/03 has a reported detection for methylene chloride (8 ug/L) and all positive results for methylene chloride should be qualified with a B for the potential of false positive results due to field cross contamination.

No trip blank samples were collected during this field event. The potential for cross contamination between samples during collecting and shipping cannot be determined. Since none of the VOC samples has very high levels of contamination reported the likelihood of cross contamination is determined to be minor there is no impact on the usability of the data.

1.2.2 SVOCs

Bis(2-ethylhexyl)phthalate is detected (89 ug/Kg) in the laboratory method blank for SDG B1235. All positive results less than 450 ug/Kg for samples in SDG B1235 are qualified as non-detect due to potential false positive results from laboratory contamination.

Bis(2-ethylhexyl)phthalate is detected (5 ug/L) in the equipment rinsate blank collected on July 28, 2003. Bis(2-ethylhexyl)phthalate is also detected in the aqueous (3 ug/L) and solid (49 ug/Kg) laboratory blank samples for SDG B1229. The equipment blank contamination is likely due to laboratory contamination and all samples with positive results for bis(2-ethylhexyl)phthalate should be qualified 'B' for blank contamination and all positive results < 250 ug/Kg should be qualified as non detect 'U' due to the potential for false positives from laboratory blank contamination.

1.3 Field and Laboratory Duplicate Precision

1.3.1 VOCs

The field duplicate (SWOS-1(1.5-3)) sample results do not meet criteria for reproducibility (<50% RPD). The RPD for detected compounds are 67% for methylene chloride, 143% for 2-butanone, and 67% for naphthalene. The results for methylene chloride, 2-butanone and naphthalene are qualified as estimated due to uncertainty in the reported results.

1.3.2 SVOCs

The field duplicate sample, SWOS-1(1.5-3), results did not meet criteria for reproducibility for fluoranthene (73.7%), pyrene (80%), benzo(a)anthracene (72.7%), chrysene (76.4%), benzo(b)fluoranthene (80.3%) and benzo(a)pyrene (78.3%). The results for these compounds in sample SWOS-1(1.5-3) should be qualified as estimated due to the uncertainty in the reported results.

1.3.3 PAHs

The field duplicate sample, SWOS-1(1.5-3), results did not meet criteria for reproducibility for pyrene (114.9%), benzo(a)anthracene (65.2%), benzo(b)fluoranthene (62.3%), benzo(k)fluoranthene (63.6%), benzo(a)pyrene (56.7%), indeno(1,2,3-cd)pyrene (68.9%), dibenz(a,h)anthracene (70.3%) and benzo(g,h,i)perylene (73.5%). The results for these compounds in sample SWOS-1(1.5-3) should be qualified as estimated due to the uncertainty in the reported results.

1.3.4 Metals

The laboratory duplicate results do not meet criteria for Lead (31.2%) and Silver (25.6%) in SDG B1235. All results for Lead and Silver in SDG B1235 are qualified as estimated due to uncertainty in the results. The results are usable for project purposes.

1.4 MS/MSD Recovery and Relative Percent Difference (RPD)

The following analytes did not meet criteria for recovery and/or reproducibility in the VOC matrix spike and matrix spike duplicate samples (SWOS-1(1.5-3)).

Table A-1
MS/MSD Recovery and Relative Percent Difference for VOCs

Compound	MS %R	MSD %R	RPD	Action
Dichlorofluoromethane	56			J
Chloromethane	123			J
Trichlorofluoromethane	62		43	J
Acetone	192	443	79	J
Methylene chloride	59			J
Methyl tert butyl ether	141	152		J
1,1-dichloroethane	123	130		J
2-butanone		200		J
Cis-1,2-dichloroethene		117		J
Bromochloromethane		135		J
Chloroform		126		J
1,2-dichloroethane		130		J
Bromodichloromethane	123			J
1,2-dichloropropane	128	139		J
Dibromomethane	128	135		J
Bromodichloromethane	120	130		J
1,1,2-trichloroethane	128	139		J
1,3-dichloropropane	144	161		J
2-hexanone	138	148		J
Dibromochloromethane	131	148		J
1,2-dibromoethane	128	135		J
1,1,1,2-tetrachloroethane	123	139		J
Bromoform		130		J
1,1,2,2-tetrachloroethane	195	217		J
Bromobenzene	126	135		J
1,2,3-trichloropropane	174	196		J
1,2-dibromo-3-chloropropane	141	152		J
Hexachlorobutadiene	44	52		J

1.4.1 SVOCs

The following analytes did not meet criteria for recovery and/or reproducibility in the SVOC matrix spike and matrix spike duplicate samples (SWOS-1(1.5-3)).

Table A-2
MS/MSD Recovery and Relative Percent Difference for SVOCs

Compound	MS %R	MSD %R	RPD	Action
4-chloro-3-methylphenol	53			J
2,4,5-trichlorophenol	51			J
2-nitroaniline	53			J
Dimethylphthalate	53			J
2,6-dinitrotoluene	58			J
4-nitrophenol	44			J
Dibenzofuran	58			J
2,4-dinitrotoluene	58		42	J
Diethylphthalate	58			J
4,6-dinitro-2-methylphenol	32			J
Dimethylphthalate		60		J
4-bromophenyl-phenylether	58	65		J
Hexachlorobenzene	63	65		J
Pentachlorophenol	12	18		J
Phenanthrene	60		49	J
di-n-butylphthalate	58	60		J
Fluoranthene	57			J
Pyrene	57		49	J
Butylbenzylphthalate	53	60		J
Bis(2-ethylhexyl)phthalate	54	61		J
di-n-octylphthalate	58			J
Benzo(b)fluoranthene	58			J
Benzo(a)pyrene	59			J
Indeno(1,2,3-cd)pyrene	53			J
Dibenzo(a,h)anthracene	48	55		J

1.4.2 PAHs

The recoveries of analytes in the MS and MSD samples for the PAH analysis were generally below criteria for all compounds. The reported results for sample SWOS-1(1.5-3) should be considered to be estimated to low bias, potential false negatives. The results are usable for project purposes.

1.4.3 Metals

Aluminum (32.7%) and Lead (68.0%) are recovered low in the matrix spike collected with the field samples. All sample results for SDG B1229 and B1235 are qualified as estimated due to potential low bias, possible false negatives, in the results due to matrix interference. The low bias does not impact the usability of the data.

1.5 Surrogate Standard Recoveries

1.5.1 VOCs

The following samples have more than one surrogate recovered outside of criteria.

Table A-3
Surrogate Standard Recoveries for VOCs

Sample	Surrogates Low	Surrogates High	Action
SWOS-4(1.5-3)	1	2	J(+)
SWOS-3(1.5-3)	0	3	J(+)
SWOS-1(1.5-3)	0	1	J(+)
SWOS-4(1.5-3)	1	2	J(+)
SWOS-3(1.5-3)	0	1	J(+)
SWOS-3(0-1.5)	0	1	J(+)
SWOS-6(0-1.5)	0	1	J(+)
SWOS-2(1.5-3)	0	1	J(+)
SWOS-10(0-1.5)	0	1	J(+)
SWOS-10(0-1.5)Re	0	1	J(+)

1.5.2 SVOCs

The following samples have more than 1 surrogate recovered outside of criteria.

Table A-4
Surrogate Standard Recoveries for SVOCs

Sample	Surrogates Low	Surrogates High	Action
SWOS-6(1.5-3)	3		J
SWOS-5(1.5-3)	2		J

1.5.3 Pesticides

The following samples have surrogates recovered outside of criteria.

Table A-5
Surrogate Standard Recoveries for Pesticides

Sample	Tetrachloro-m-xylene	Decachlorobiphenyl	Action
SWOS-5(1.5-3)		1 low	J
SWOS-4(1.5-3)		1 low	J
SWOS-3(0-1.5)		1 high	J(+)
SWOS-9(1.5-3)		2 high	J(+)
SWOS-8(1.5-3)	1 high		J(+)
SWOS-2(0-1.5)		1 high	J(+)
SWOS-1(1.5-3)		2 low	J

1.5.4 PCBs

The following samples have surrogates recovered outside of criteria.

Table A-6
Surrogate Standard Recoveries for PCBs

Sample	Tetrachloro-m-xylene	Decachlorobiphenyl	Action
SWOS-9(1.5-3)		2 high	J(+)

1.6 Laboratory Control Samples

1.6.1 VOCs

The following analytes did not meet criteria for recovery in the VOC laboratory control samples.

Table A-7
Laboratory Control Samples for VOCs

LCS	Analytes	Recovery	Limits	Action	Samples Affected
V2WLCS	Cis-1,2-dichloroethene	116		J	SWOS-8(1.5-3) SWOS-7(1.5-3) SOWS-6(0-1.5) SWOS-6(1.5-3) SWOS-2(0-1.5) SWOS-2(1.5-3) Field Dup
V2ZLCS	1,2-dichloropropane	118		J	

1.6.2 SVOCs

The analytes in Table A-8 did not meet criteria for recovery in the SVOC laboratory control samples.

1.6.3 PAHs

Naphthalene (46%), fluorene (46%) and fluoranthene (48%) were recovered low in the laboratory control sample analyzed with the field equipment rinsate blank. The non detect results for naphthalene, fluorene and fluoranthene are considered to be estimated due to potential low bias, false negatives. The results are considered to be usable for project purposes.

1.6.4 Pesticides

The recovery of delta-BHC (31%) did not meet method criteria. The reported result for delta-BHC in sample SWOS-1(1.5-3) should be considered as estimated due to potential low bias, possible false negative. The result is usable for project purposes.

1.6.5 Metals

Silver (120.2%) was recovered above criteria for a laboratory control sample analyzed with the SDG B1235. All positive reported results for silver for samples in SDG B1235 are qualified as estimated due to the potential high bias, false positive results. The results are usable for project purposes.

Table A-8
Laboratory Control Samples for SVOCs

LCS	Analytes	Recovery	Limits	Action	Samples Affected
S4ZLCS	2-nitroaniline	59		J	SWOS-9(0-1.5)
	4-bromophenyl-phenylether	59		J	SWOS-10(0-1.5)
	Hexachlorobenzene	65		J	SWOS-10(1.5-3)
	di-n-butylphthalate	57		J	SWOS-8(0-1.5)
	Pyrene	65		J	
	Butylbnzylphthalate	54		J	
	Bis(2-ethylhexyl)phthalate	55		J	
	di-n-octylphthalate	53		J	
S2FLCS	2,4-Dinitrophenol	0		R	SWOS-2(0-1.5)
	4,6-dinitro-2-methylphenol	16		J	SWOS-7(0-1.5)
	di-n-octylphthalate	65		J	SWOS-2(1.5-3)
					SWOS-1(1.5-3)
					SWOS-8(1.5-3)
					SWOS-6(1.5-3)
					SWOS-6(0-1.5)
					SWOS-3(0-1.5)
					SWOS-3(1.5-3)
					SWOS-5(1.5-3)
					SWOS-4(1.5-3)
					SWOS-7(1.5-3)
					SWOS-1(0-1.5)
					SWOS-4(0-1.5)
					SWOS-5(0-1.5)
S2MLCS	4,6-dinitro-2-methylphenol	28		J	SWOS-9(1.5-3)
					SWOS-7(1.5-3)
					SWOS-1(0-1.5)
					SWOS-4(0-1.5)
					SWOS-5(0-1.5)
S2MLCSD	2,4-dinitrophenol	6		R	SWOS-9(1.5-3)
	4,6-dinitro-2-methylphenol	17		J	SWOS-7(1.5-3)
					SWOS-1(0-1.5)
					SWOS-4(0-1.5)
					SWOS-5(0-1.5)

1.7 Internal Standard Areas

1.7.1 VOCs

The following samples did not have internal standard (IS) responses that met method criteria for the VOC analysis.

Table A-9
Internal Standard Areas for VOCs

Samples	IS High (>200%)	IS Low (< 50%)	Action
SWOS-5(1.5-3)		3	J
SWOS-4(0-1.5)		1	J
SWOS-4(1.5-3)		3	J
SWOS-3(0-1.5)		2	J
SWOS-3(1.5-3)		3	J
SWOS-9(1.5-3)		2	J
SWOS-8(1.5-3)		3	J
SWOS-7(1.5-3)		2	J
SWOS-6(0-1.5)		3	J
SWOS-2(1.5-3)		3	J
SWOS-1(1.5-3)	1		J(+)
FIELD DUP	1		J(+)
SWOS-5(0-1.5)		2	J
SWOS-4(1.5-3)		3	J
SWOS-3(1.5-3)		1	J
SWOS-8(1.5-3)		3	J

1.7.2 SVOCs

The following samples did not have internal standard responses that met method criteria for the SVOC analysis.

Table A-10
Internal Standard Areas for SVOCs

Samples	IS High (>200%)	IS Low (< 50%)	Action
SWOS-4(0-1.5)		1	J
SWOS-5(0-1.5)		2	J

1.8 PCB and Pesticide Target Compound Identification

The following compounds do not meet criteria for precision between analytical column results.

Table A-11
PCB and Pesticide Target Compound Identification

Sample	Analyte	% D	Action
SWOS-4(1.5-3)	Aldrin	117.5	J
SWOS-6(0-1.5)	4,4-DDE	48.3	J
SWOS-6(1.5-3)	4,4-DDE	66.7	J
SWOS-9(1.5-3)	4,4-DDE	32.2	J
	Alpha-chlordane	42.8	J
	Gamma-chlordane	41.5	J
SWOS-8(0-1.5)	4,4'-DDE	37	J

1.8.1 ICP Serial Dilutions

The serial dilution sample for SDG B1235 does not meet criteria for Barium (12.9%), Cadmium (33.6%), Cobalt (10.6%), Lead (10.8%), Magnesium (11.0%), Manganese (11.1%) and Zinc (12.9%). All results for Barium, Cadmium, Cobalt, Lead, Magnesium, Manganese and Zinc are qualified as estimated due to uncertainty in the results.

Appendix B
Intake Calculations for the Construction Worker Soil Exposures

Table: B-1
 Site: SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND
 Scenario Timeframe: Future
 Medium: Soil
 Exposure Medium: Soil
 Receptor Population: Construction Worker
 Receptor Age: Adult
 Exposure Route: Incidental Ingestion

$$\text{INTAKE} = \frac{\text{Exposure Point Concentration in Soil}}{\text{mg/kg-day}} \times \frac{\text{Soil Ingestion Rate}}{\text{mg/day}} \times \text{Exposure Frequency} \times \text{Exposure Duration} \times \frac{\text{Conversion Factor 1}}{\text{kg/mg}} \times \frac{1}{\text{Body Weight}} \times \frac{1}{\text{Averaging Time-Cancer}}$$

Variable Symbols = CS IR-S EF ED CF1 BW AT-C
 Parameter Values = Site-Specific 480 48 1 1.E-06 70 25,550
 Parameter Units = mg/kg mg/day days/year years kg/mg kg days

Exposure Point	Chemical of Concern	Exposure Point Concentration in Soil mg/kg	Soil Ingestion Rate mg/day	Exposure Frequency days/year	Exposure Duration years	Conversion Factor 1 kg/mg	Body Weight kg	Averaging Time- Cancer days	INTAKE mg/kg-day
Soil	4-Isopropyltoluene	0.00044	480	48	1	1.E-06	70	25,550	5.7E-12
	Iodomethane	0.000844	480	48	1	1.E-06	70	25,550	1.1E-11
	Benzo(a)pyrene	0.216	480	48	1	1.E-06	70	25,550	2.8E-09
	Benzo(b)fluoranthene	0.286	480	48	1	1.E-06	70	25,550	3.7E-09
	Benzo(g,h,i)perylene	0.22	480	48	1	1.E-06	70	25,550	2.8E-09
	Dibenzo(a,h)anthracene	0.066	480	48	1	1.E-06	70	25,550	8.5E-10
	Phenanthrene	0.255	480	48	1	1.E-06	70	25,550	3.3E-09
	Aluminum	12475	480	48	1	1.E-06	70	25,550	1.6E-04
	Arsenic	9.27	480	48	1	1.E-06	70	25,550	1.2E-07
	Lead	42	480	48	1	1.E-06	70	25,550	5.4E-07
	Manganese	401	480	48	1	1.E-06	70	25,550	5.2E-06

Table B-2
Site SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND
Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Receptor Population: Construction Worker
Receptor Age: Adult
Exposure Route: Dermal Absorption

INTAKE = mg/kg-day	Exposure Point Concentration In Soil	x	Skin Surface Area Available for Contact	x	Dermal Absorption Factor (Solid)	x	Soil to skin adherence factor	x	Exposure Frequency	x	Exposure Duration	x	Conversion Factor 1	x	$\frac{1}{\text{Body Weight}}$	x	$\frac{1}{\text{Averaging Time-Cancer}}$
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Variable Symbols =	CS	SA	DABS	SSAF	EF	ED	CF1	BW	AT-C
Parameter Values =	Site-Specific	7,014	Chemical-Specific	0.08	48	1	1 E-06	70	25,550
Parameter Units =	mg/kg	cm ² /day	unitless	mg/cm ²	days/year	years	kg/mg	kg	days

Exposure Point	Chemical of Concern	Exposure Point Concentration In Soil mg/kg	Skin Surface Area Available for Contact cm ² /day	Dermal Absorption Factor (Solid) unitless	Soil to skin adherence factor mg/cm ²	Exposure Frequency days/year	Exposure Duration years	Conversion Factor 1 kg/mg	Body Weight kg	Averaging Time- Cancer days	INTAKE mg/kg-day
Soil	4-Isopropyltoluene	0.00044	7,014	N/A	0.08	48	1	1 E-06	70	25,550	N/A
	Iodomethane	0.000844	7,014	N/A	0.08	48	1	1 E-06	70	25,550	N/A
	Benzo(a)pyrene	0.216	7,014	0.13	0.08	48	1	1 E-06	70	25,550	4.2E-10
	Benzo(b)fluoranthene	0.288	7,014	0.13	0.08	48	1	1 E-06	70	25,550	5.6E-10
	Benzo(g,h,i)perylene	0.22	7,014	0.13	0.08	48	1	1 E-06	70	25,550	4.3E-10
	Dibenzo(a,h)anthracene	0.068	7,014	0.13	0.08	48	1	1 E-06	70	25,550	1.3E-10
	Phenanthrene	0.255	7,014	0.13	0.08	48	1	1 E-06	70	25,550	5.0E-10
	Aluminum	12475	7,014	N/A	0.08	48	1	1 E-06	70	25,550	N/A
	Arsenic	9.27	7,014	0.03	0.08	48	1	1 E-06	70	25,550	4.2E-09
	Lead	42	7,014	N/A	0.08	48	1	1 E-06	70	25,550	N/A
	Manganese	401	7,014	N/A	0.08	48	1	1 E-06	70	25,550	N/A
Notes:											
N/A - Not Applicable											

Table: B-3
 Site: SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND
 Scenario Timeframe: Future
 Medium: Soil
 Exposure Medium: Soil
 Receptor Population: Construction Worker
 Receptor Age: Adult
 Exposure Route: Inhalation

$$\text{INTAKE} = \frac{\text{Exposure Point Concentration in Soil}}{\text{mg/kg-day}} \times \frac{1}{\text{Particulate Emission Factor}} \times \text{Inhalation Rate} \times \text{Exposure Time} \times \text{Exposure Frequency} \times \text{Exposure Duration} \times \frac{1}{\text{Body Weight}} \times \frac{1}{\text{Averaging Time-Cancer}}$$

Variable Symbols = CS PEF IN ET EF ED BW AT-C
 Parameter Values = Site-Specific 1.32E+09 3.3 8 48 1 70 25,550
 Parameter Units = mg/kg m3/kg m3/hr hour/day days/year years kg days

Exposure Point	Chemical of Concern	Exposure Point Concentration in Soil mg/kg	Particulate Emission Factor m3/kg	Inhalation Rate m3/hr	Exposure Time hour/day	Exposure Frequency days/year	Exposure Duration years	Body Weight kg	Averaging Time-Cancer days	INTAKE mg/kg-day
Soil	4-Isopropyltoluene	0.00044	1.3E+09	3.3	8	48	1	70	25,550	2.4E-16
	Iodomethane	0.000844	1.3E+09	3.3	8	48	1	70	25,550	4.5E-16
	Benzo(a)pyrene	0.216	1.3E+09	3.3	8	48	1	70	25,550	1.2E-13
	Benzo(b)fluoranthene	0.286	1.3E+09	3.3	8	48	1	70	25,550	1.5E-13
	Benzo(g,h,i)perylene	0.22	1.3E+09	3.3	8	48	1	70	25,550	1.2E-13
	Dibenzo(a,h)anthracene	0.066	1.3E+09	3.3	8	48	1	70	25,550	3.5E-14
	Phenanthrene	0.255	1.3E+09	3.3	8	48	1	70	25,550	1.4E-13
	Aluminum	12475	1.3E+09	3.3	8	48	1	70	25,550	6.7E-09
	Arsenic	9.27	1.3E+09	3.3	8	48	1	70	25,550	5.0E-12
	Lead	42	1.3E+09	3.3	8	48	1	70	25,550	2.3E-11
	Manganese	401	1.3E+09	3.3	8	48	1	70	25,550	2.2E-10

Table: B-4
 Site: SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND
 Scenario Timeframe: Future
 Medium: Soil
 Exposure Medium: Soil
 Receptor Population: Construction Worker
 Receptor Age: Adult
 Exposure Route: Incidental Ingestion

$$\text{INTAKE} = \frac{\text{Exposure Point Concentration in Soil} \times \text{Soil Ingestion Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration} \times \text{Conversion Factor 1} \times \frac{1}{\text{Body Weight}} \times \frac{1}{\text{Averaging Time-Non-Cancer}}}{\text{mg/kg-day}}$$

Variable Symbols = CS IR-S EF ED CF1 BW AT-N
 Parameter Values = Site-specific 480 48 1 1.E-06 70 365
 Parameter Units = mg/kg mg/day days/year years kg/mg kg days

Exposure Point	Chemical of Concern	Exposure Point Concentration in Soil mg/kg	Soil Ingestion Rate mg/day	Exposure Frequency days/year	Exposure Duration years	Conversion Factor 1 kg/mg	Body Weight kg	Averaging Time- Non-Cancer days	INTAKE mg/kg-day
Soil	4-Isopropyltoluene	0.00044	480	48	1	1.E-06	70	365	4.0E-10
	Iodomethane	0.000844	480	48	1	1.E-06	70	365	7.6E-10
	Benzo(a)pyrene	0.216	480	48	1	1.E-06	70	365	1.9E-07
	Benzo(b)fluoranthene	0.286	480	48	1	1.E-06	70	365	2.6E-07
	Benzo(g,h,i)perylene	0.22	480	48	1	1.E-06	70	365	2.0E-07
	Dibenzo(a,h)anthracene	0.066	480	48	1	1.E-06	70	365	6.0E-08
	Phenanthrene	0.255	480	48	1	1.E-06	70	365	2.3E-07
	Aluminum	12475	480	48	1	1.E-06	70	365	1.1E-02
	Arsenic	9.27	480	48	1	1.E-06	70	365	8.4E-06
	Lead	42	480	48	1	1.E-06	70	365	3.8E-05
	Manganese	401	480	48	1	1.E-06	70	365	3.6E-04

Table: B-5
 Site: SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND
 Scenario Timeframe: Future
 Medium: Soil
 Exposure Medium: Soil
 Receptor Population: Construction Worker
 Receptor Age: Adult
 Exposure Route: Dermal Absorption

$$\text{INTAKE} = \frac{\text{mg}}{\text{kg-day}} = \text{Exposure Point Concentration in Soil} \times \text{Skin Surface Area Available for Contact} \times \text{Dermal Absorption Factor (Solid)} \times \text{Soil to skin adherence factor} \times \text{Exposure Frequency} \times \text{Exposure Duration} \times \text{Conversion Factor 1} \times \frac{1}{\text{Body Weight}} \times \frac{1}{\text{Averaging Time-Non-Cancer}}$$

Variable Symbols = CS SA DABS SSAF EF ED CF1 BW AT-N
 Parameter Values = Site-specific 7,014 Chemical-specific 0.08 48 1 1 E-06 70 365
 Parameter Units = mg/kg cm2/day unitless mg/cm2 days/year years kg/mg kg days

Exposure Point	Chemical of Concern	Exposure Point Concentration in Soil mg/kg	Skin Surface Area Available for Contact cm2/day	Dermal Absorption Factor (Solid) unitless	Soil to skin adherence factor mg/cm2	Exposure Frequency days/year	Exposure Duration years	Conversion Factor 1 kg/mg	Body Weight kg	Averaging Time-Non-Cancer days	INTAKE mg/kg-day
Soil	4-Isopropyltoluene	0.00044	7,014	N/A	0.08	48	1	1 E-06	70	365	N/A
	Iodomethane	0.000844	7,014	N/A	0.08	48	1	1 E-06	70	365	N/A
	Benzo(a)pyrene	0.216	7,014	0.13	0.08	48	1	1 E-06	70	365	3.0E-08
	Benzo(b)fluoranthene	0.288	7,014	0.13	0.08	48	1	1 E-06	70	365	3.9E-08
	Benzo(g,h,i)perylene	0.22	7,014	0.13	0.08	48	1	1 E-06	70	365	3.0E-08
	Dibenzo(a,h)anthracene	0.066	7,014	0.13	0.08	48	1	1 E-06	70	365	9.0E-09
	Phenanthrene	0.255	7,014	0.13	0.08	48	1	1 E-06	70	365	3.5E-08
	Aluminum	12475	7,014	N/A	0.08	48	1	1 E-06	70	365	N/A
	Arsenic	9.27	7,014	0.03	0.08	48	1	1 E-06	70	365	2.9E-07
	Lead	42	7,014	N/A	0.08	48	1	1 E-06	70	365	N/A
	Manganese	401	7,014	N/A	0.08	48	1	1 E-06	70	365	N/A

Notes:
 N/A - Not Applicable

Table: B-6
 Site: SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND
 Scenario Timeframe: Future
 Medium: Soil
 Exposure Medium: Soil
 Receptor Population: Construction Worker
 Receptor Age: Adult
 Exposure Route: Inhalation

$$\text{INTAKE} = \frac{\text{mg}}{\text{kg-day}} = \text{Exposure Point Concentration in Soil} \times \frac{1}{\text{Particulate Emission Factor}} \times \text{Inhalation Rate} \times \text{Exposure Time} \times \text{Exposure Frequency} \times \text{Exposure Duration} \times \frac{1}{\text{Body Weight}} \times \frac{1}{\text{Averaging Time-Non-Cancer}}$$

Variable Symbols = CS PEF IN ET EF ED BW AT-N
 Parameter Values = Site-Specific 1.32E+09 3.3 8 48 1 70 365
 Parameter Units = mg/kg m3/kg m3/hr hour/day days/year years kg days

Exposure Point	Chemical of Concern	Exposure Point Concentration in Soil mg/kg	Particulate Emission Factor m3/kg	Inhalation Rate m3/hr	Exposure Time hour/day	Exposure Frequency days/year	Exposure Duration years	Body Weight kg	Averaging Time-Non-Cancer days	INTAKE mg/kg-day
Soil	4-Isopropyltoluene	0.00044	1.3E+09	3.3	8	48	1	70	365	1.7E-14
	Iodomethane	0.000844	1.3E+09	3.3	8	48	1	70	365	3.2E-14
	Benzo(a)pyrene	0.216	1.3E+09	3.3	8	48	1	70	365	8.1E-12
	Benzo(b)fluoranthene	0.286	1.3E+09	3.3	8	48	1	70	365	1.1E-11
	Benzo(g,h,i)perylene	0.22	1.3E+09	3.3	8	48	1	70	365	8.3E-12
	Dibenzo(a,h)anthracene	0.066	1.3E+09	3.3	8	48	1	70	365	2.5E-12
	Phenanthrene	0.255	1.3E+09	3.3	8	48	1	70	365	9.6E-12
	Aluminum	12475	1.3E+09	3.3	8	48	1	70	365	4.7E-07
	Arsenic	9.27	1.3E+09	3.3	8	48	1	70	365	3.5E-10
	Lead	42	1.3E+09	3.3	8	48	1	70	365	1.6E-09
	Manganese	401	1.3E+09	3.3	8	48	1	70	365	1.5E-08

Table: B-7
 Chemical-Specific Factors
 Site: SWOS SITE, NAVAL STATION NEWPORT, PORTSMOUTH, RHODE ISLAND

Chemical Group	Chemical of Concern	Dermal Absorption Fraction (1) unitless
	4-Isopropyltoluene	N/A
	Iodomethane	N/A
	Benzo(a)pyrene	0.13
	Benzo(b)fluoranthene	0.13
	Benzo(g,h,i)perylene	0.13
	Dibenzo(a,h)anthracene	0.13
	Phenanthrene	0.13
	Aluminum	N/A
	Arsenic	0.03
	Lead	N/A
	Manganese	N/A

Sources:

- (1) USEPA, 2001. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance. - Exhibit 3.4.